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No. 6. New Series. April 1878. [2s. 6d.

THE POPULAR Science Review

EDITED BY W. S. DALLAS, F.L.S.

Assistant-Secretary of the Geological Society.

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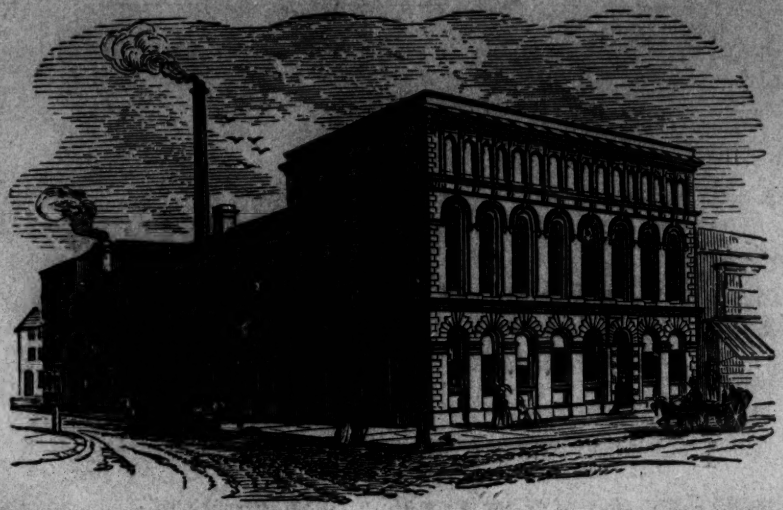

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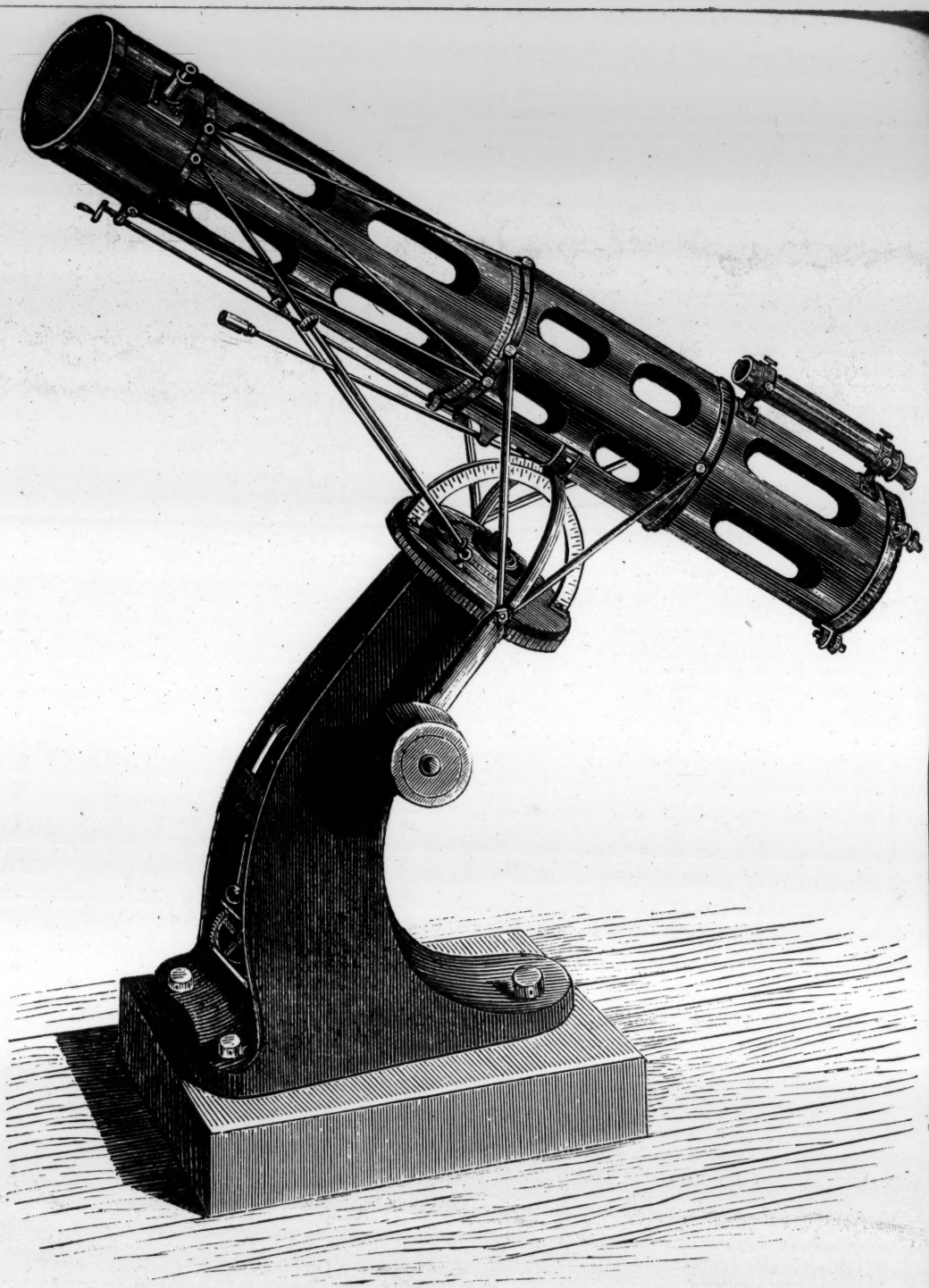

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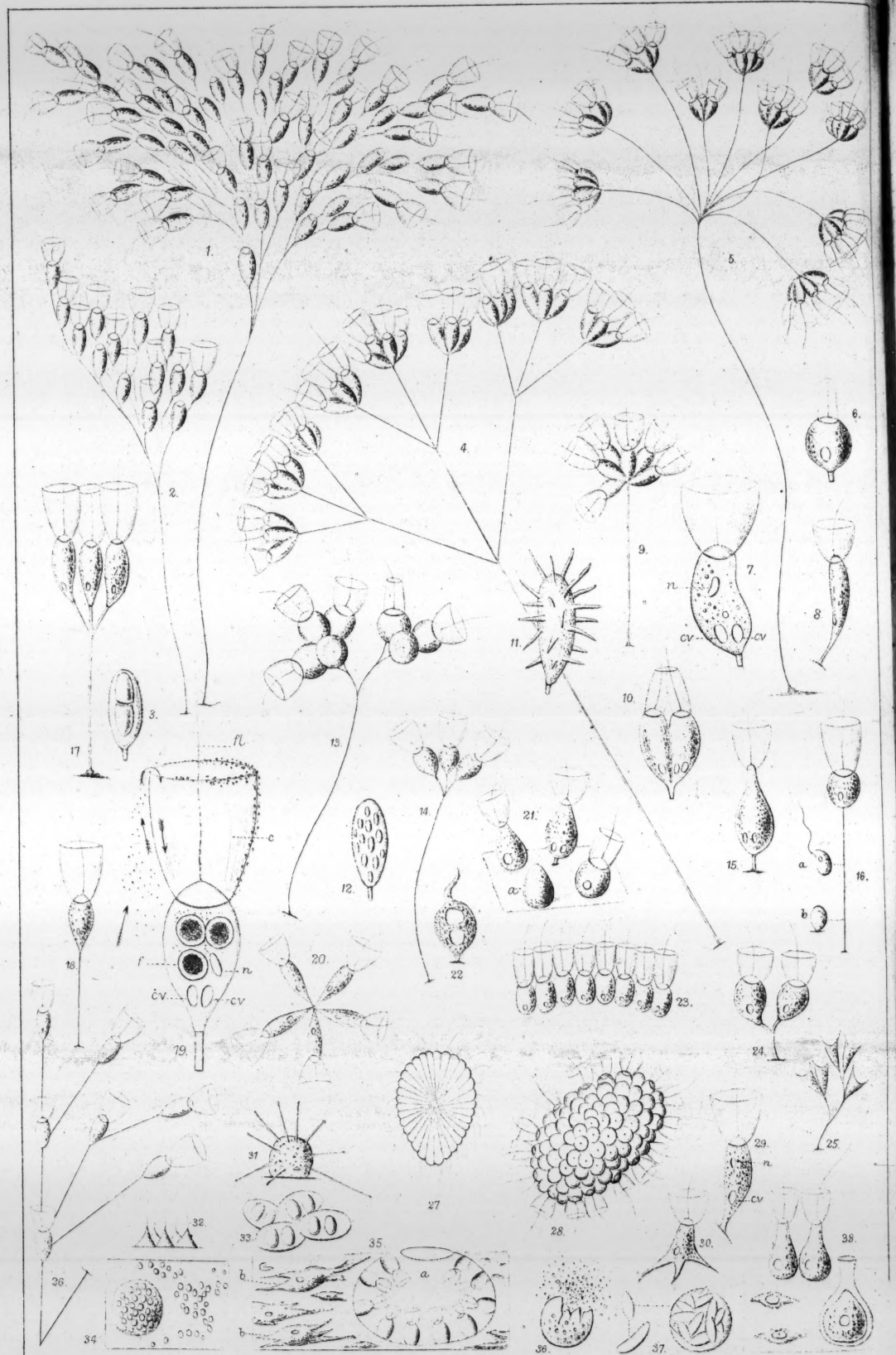

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Flagellate Protozoa

A NEW FIELD FOR THE MICROSCOPIST.

By W. SAVILLE KENT, F.L.S., F.Z.S., F.R.M.S.

[PLATES III. AND IV.]

IN no department of mechanical science, probably, during the last few years, has the march of progress been productive of more conspicuous and substantial fruits than in that one associated with the construction and perfection of the higher magnifying powers of the compound microscope. It is but a short while, indeed, since an amplification of some 500 linear diameters was about the utmost that could be safely relied upon by the microscopist for the accurate interpretation of independent minute organisms, or for investigating the ultimate structure of more highly complex tissues. Now, however, thanks to the mechanical and scientific skill of both English and foreign manufacturers specially devoted to this branch of optics, our range of vision among the atomic elements of this wondrous world has been extended to an almost incredible degree. A magnifying power of 2,000 or 3,000 diameters is in these days at the disposal of the merest tyro, while Messrs. Powell and Lealand, the opticians of this country to whom the palm of merit for the construction of object-glasses of the highest magnification is almost universally accorded, are able to produce a lens yielding with their deepest eyepiece an amplification of no less than 15,000 linear. To work successfully with a one-fiftieth inch objective and No. 5 eyepiece, the combination giving this marvellous magnification, or indeed to see anything with such a glass, belongs, as might be anticipated, to the professional expert only. A one-sixteenth inch objective, however, capable of yielding the more moderate but still considerably advanced amount of magnification previously named, is at the present date as accessible from a pecuniary point, and after a little practice is as convenient to work with as an ordinary one-quarter inch glass of the best construction.

It would be a matter for congratulation if we could place on record side by side with this attestation to the mechanical perfection and improvements of our magnifying instruments,

evidence of an equivalent amount of progress achieved by microscopic workers in those new fields for investigation thrown open to them by the skill of the optician. With humiliation it is, however, necessary to admit that these new and high-class magnifying powers, distributed as they now are broadcast throughout the land, are destined in the majority of instances to fulfil a most unimportant if not ignoble *rôle*. Boxed up in the cabinet of their possessor, they rarely see the light, except, maybe, for the purpose of a more often than otherwise abortive attempt to resolve the dots or striæ upon the siliceous shell of some obscure and vexatious diatom, further weighted or handicapped in many instances by immersion in a medium intentionally employed for the purpose of rendering previous obscurity still more obscure; or again, perhaps, for an exposition of the owner's views of the nature of the markings upon a Podura scale, or for an attempted solution of some occult question of angular aperture. Granted, that the accomplishment of such trivial ends, and the emulation entertained among amateur microscopists to possess a lens that shall outstrip their neighbours' in the perfection of its defining power, has contributed in no small degree towards the highest triumphs of the optician in this department, it is still greatly to be deplored that so much latent power of discovery should thus lie year after year, like the golden talent of tradition, buried in a napkin. Surely, among the myriads of minute organisms at the base of the animal and vegetable worlds, there is room enough and to spare for valuable and even original investigation! Here, indeed, the harvest-field is full to the overflowing, and to any entering upon it in a scientific spirit, possessing ordinary dexterity of manipulation and some rudimentary knowledge of the forms he is likely to encounter, may be promised a reward far more gratifying to himself and more useful to his fellow-workers than he can achieve by a lifetime devoted to the solution of the markings on a frustule of *Surirella gemma* or on the scales of *Lepidocyrtis curvicollis*. 'Il n'est que le premier pas qui coûte' —and here as elsewhere the chief obstacle experienced by the amateur worker, armed with his new high-power objective, and ardent to win his spurs as an original discoverer, is beyond doubt the selection of a subject. In recognition of this difficulty of making a commencement, and also of the assistance and encouragement that may often be derived from the narration of personal experience gained in the striking out of a novel field, a brief account will here be given of some of the results of a rather successful forage or series of forages conducted by the writer during leisure hours within the last few years, in association with certain newly discovered or previously little known Flagellate Protozoa; all these forms again, without exception, requiring for their satisfactory interpretation the employment of those

powerful and high-class magnifying powers referred to in our opening sentence.

It will no doubt be remembered by many readers of this Journal that certain members of the Flagellate Protozoa, embracing several of those free-swimming monads which occur abundantly in fish- and other animal-macerations, have already been brought before their notice.* On this occasion, however, it is proposed to give a brief descriptive outline, with illustrations, of an extensive series of forms that have so far, on account of their exceedingly minute size, altogether evaded the notice of the microscopists of this country, but which at the same time most certainly surpass all previously discovered types equally in the wonderful symmetry of their individual form and in that of their aggregated mode of growth. So long ago as the year 1866 a few stray members of this Flagellate group, to which attention will now be directed, were made known to the American scientific world by Professor H. James Clark, of Pennsylvania, U.S.A., who described and figured four species only, three of these inhabiting fresh-, and the remaining one salt-water. Most unfortunately for science this authority did not long survive his discovery of these new forms, and had, consequently, no opportunity of further extending and fully maturing his acquaintance with the same. Since the death of Professor Clark no other investigator, with the exception of the contributor of this article, appears to have knowingly encountered a single representative of the group in question, which may thus be said to have vanished from scientific cognizance.

The first acquaintance made by the writer with the new group of Flagellate Monads now to be introduced was in the autumn of the year 1871, when occupied in investigating the infusorial fauna of a small pond situated in the North London district, and fed by water from the New River Company. What at first sight during these researches presented the aspect of numerous closely aggregated colonies of a minute species of *Epistylis*, resembling the *E. botrytis* of Ehrenberg, proved upon more accurate examination and with the aid of a magnification of about 700 diameters, to be identical with the new type introduced by Professor Clark a few years previously, under the title of *Codosiga pulcherrima*. A representation of this earliest discovered and very elegant compound pedicellate monad will be found at Plate III. fig. 9, accompanying this article. The identity and structural peculiarity of this type having been once recognized, a very brief investigation sufficed to detect in the water of this same pond the whole of the three fresh-water species originally found

* See article on "Recent Researches in Minute Life," by H. J. Slack, F.G.S., Pop. Sc. Rev., vol. xiv. p. 245. 1875.

and described by Professor Clark, and in addition, a fourth and still more remarkable and luxuriant-growing variety. A brief announcement of this discovery within British waters of these interesting Flagellate types, with notes upon a few other allied forms, was communicated to the November meeting of the Royal Microscopical Society of London, and appeared in the Society's Journal for January 1872. From that period up to the present date continued researches by the writer in the same fertile field have been so far rewarded that the borders of this interesting, and as now shown widely distributed group, have had to be extended for the admission of some forty or fifty well-marked species. From a numerical point alone, indeed, it has now been demonstrated to occupy as important a position as any of the leading and natural divisions of the lower Protozoa recognized previous to this discovery; while in structural organization they are found to exhibit so novel an aspect as to demand the creation of a new sectional title equivalent to that of an order, if not a class, for their reception.

A glance at the two plates illustrating this article (perhaps already taken), will at once place the reader *en rapport* with the essential characteristics and more important known varieties of this newly discovered group, and which are here reproduced with considerable reduction in both size and number from the fuller details that accompany an extended monograph of the same now awaiting publication.* The most prominent feature of all these types, and one that serves to conspicuously distinguish them from all previously known Protozoic forms, is the presence at the anterior extremity of each individual monad of a hyaline, wineglass-shaped expansion, from the centre of the base of which the long lash-like flagellum takes its origin. On this remarkable wineglass-shaped structure Professor Clark originally bestowed the appropriate title of the 'collar,' and by this appellation it will hereafter be distinguished. Specifically, this delicate hyaline organ, the collar, is of such extreme tenuity that its true form and nature can be brought out only by a very careful adjustment of the achromatic condenser or other accessory illuminating apparatus employed, and is even then exhibited to the greatest advantage by supplying the type under examination with artificial food, such as carmine or indigo. Under the condition last premised it will be found that this collar consists of a thin infundibuliform film of sarcode that may be protruded from and withdrawn at will into the general substance of the monad's body in the same manner as the sarcode prolongations

* These fuller details are embodied in "A Monograph of the Collar-bearing Flagellata, &c., &c." communicated to the meeting of the Linnean Society held June 21, 1877.

or pseudopodia of an amœba or other Rhizopod. As in the pseudopodia of certain Rhizopods, such as the Foraminifera, it will likewise be found that notwithstanding the extreme tenuity of this sarcode film, a circulation of its substance is being constantly maintained, flowing upwards on the outside, over the distal edge or rim, and downwards on the inner surface, at the base of which it again comes in contact and merges with the general sarcode of the body. The services performed by this wineglass-like film of sarcode as a branchial or respiratory organ are doubtless considerable, but this by no means represents its most important function. In conjunction with the centrally enclosed vibratile flagellum it represents the most admirable trap or snare for the capture and retention of food that can be possibly imagined. Whirling round with inconceivable rapidity this last-named organ, the flagellum, creates a strong current in the water, setting from behind forwards in the direction of its own apex, and bringing with it all such tiny organic particles as do not possess sufficient power to stem its tide. But for the outspread collar these atomic particles would simply hurry with the stream past the monad's body and out of reach. Not for them, however, such an easy passing of the rapids. The dangers of dread Scylla lurk midway in the whirlpool of Charybdis! In the midst of their swift career they strike against the outer surface of the almost impalpable film of sarcode of which the collar is composed, and to this they now adhere as tenaciously as the snared bird to the lime-covered twig, or an incautious fly to a spider's web. Then slowly, almost imperceptibly, the captive atoms, be they alive or dead, are carried along with the circulating current of the collar's substance, until, on reaching the base of the interior of this structure as just now described, they are there engulphed within the sarcode substance of the monad's body as within a living grave. A diagrammatic illustration of the *modus operandi* of this remarkable feeding process, and also the aspect presented by one of these monads that was induced to make a hearty meal off minute particles of carmine, will be found at Pl. III. fig. 19. The food-particles after ingestion, as above, are gradually accumulated into spherical agglomerations and then passed within the interior of the body in a manner identical with that accompanying the feeding process of Vorticella or other of the higher Infusorial types. Refuse, or undigested residual particles of food, are finally liberated from the same area, limited by the base of the collar within which they primarily gained access. In common with apparently all other representatives of the Protozoa, these minute collar-bearing monads possess from one to two or more of those rhythmically expanding and contracting spaces distinguished by the title of "contractile vesicles." With these structures there is usually

associated the function of a rudimentary heart or respiratory organ, and in this particular group they are most generally situated at the posterior extremity of the monad's body.

Passing now from such characters as are shared in common by all the members of the Flagellate group to those which serve to distinguish them individually from each other, one is amazed at the infinity of form and variation in the arrangement of similar primary elements that are presented. The essentially plant-like aspect of many of these constitutes one of their most conspicuous features, to which has also to be added the remarkable extent to which will be here found foreshadowed on a much more minute but surpassingly luxuriant scale those individual or aggregated types of growth hitherto supposed to be confined to the more highly organized Ciliate order of the Infusoria. Examined from this latter point of view, the various species of *Codosiga*, consisting of numerous individual monads grouped together on a simple or branching footstalk, immediately recall to mind the compound pelicellate colonies of *Epistylis* or *Zoothamnium*; few, however, among these latter presenting such an exuberance and symmetry of growth as is instanced by the forms *Codosiga cymosa*, *alloides*, and *umbellata*, illustrated by figs. 1, 4, and 5, on the first of the accompanying plates (Pl. III.). The solitary species, belonging to the genus *Monosiga*, again, *ib.* figs. 16 and 18, may be accepted as corresponding with the simple and initial factor of the group typified in the same higher Ciliate order by the genus *Vorticella*. This simile in association with the family of the Vorticellidæ may be carried yet further, for while among these latter there occur genera, *e.g.*, *Cothurnia* and *Vaginicola*, in which the animalcules secrete around them chitinous protective sheaths or loricæ, so likewise we find what may be regarded as an homologous structure repeated in the genus *Salpingœca* (Plate IV. figs. 2, 9, 11, &c.), though in this instance with a diversity of contour altogether unapproached in either of those higher types. This genus *Salpingœca* is alone, in fact, worthy of independent study if only on account of the exquisite variety of form presented by these protective sheaths, many of which may be said to vie in chasteness and elegance of design with the classic vases and amphoræ of the ancient Greeks. In the genus *Lagenœca* (Plate IV. fig. 42) is found a freely floating loricate type, which may be compared with the Ciliate genera *Tintinnus* or *Codonella;* while in *Polynœca* (Plate IV. fig. 1) is encountered a variety whose compound lorica resembles the polypary of a minute Sertularian Zoophyte, and which has no parallel among that higher order of the Protozoa with which previous comparisons have been instituted.

Not less interesting than the varied forms of the protective loricæ of these collar-bearing monads as above referred to, are

the protean shapes assumed at will by their minute occupants during both their adult and developmental states. A variety of the more remarkable of these will be found represented in the accompanying illustrations. Thus one of the most cosmopolitan representatives of the tribe, *Salpingœca amphoridium*, while under ordinary conditions exhibiting that aspect characteristic of all other members of the group broadly described on a preceding page, is at times, to all but the initiated, metamorphosed beyond recognition. In one of these phases (Plate IV. fig. 4) it will be seen that while the flagellum remains extended, a portion of the body-sarcode of the monad is protruded from the aperture of the lorica. A still more singular form frequently assumed by this same species is delineated at fig. 5 of the same Plate. Here both the collar and flagellum have entirely disappeared, and one-half or more of the body-substance is projected from the orifice of the lorica in the form of numerous lobate processes resembling the pseudopodia of a *Difflugia*, to which Rhizopodal type the creature now bears a close resemblance. By patiently watching an example presenting this Difflugian aspect, it was found that in a little while the protruded lobate portion became gradually separated from the posterior half, and floated away in the form of a minute stellate amœba; this subsequently attaching itself, developed a new lorica, and grew into a collar-bearing form, identical with that from which it originally sprang. The posterior half, left in the parent domicile, speedily acquiring a new collar and flagellum, is not to be distinguished from the normal aspect it presented previous to entering upon the process of transverse fission. Another and characteristic phase frequently observed in association with this same species is that quiescent, or "encysted," condition represented at Plate IV. fig. 7. During this period of its life-history all external signs of vitality are suspended, and the body of the monad shrinks into a spherical or ovoid shape within its flask-like habitation. A little later this encysted monad breaks up into numerous locomotive spore-shaped bodies, each furnished with a single flagelliform appendage. These, after dispersing themselves through the surrounding water, become attached, and growing to the likeness of the parent form lay severally the foundation of future colonies. An illustration of the liberation and dispersal of the locomotive spores or germs of an allied species, *S. fusiformis*, is given at Plate IV. fig. 26.

While the mode of increase by fissi-gemmation in the loricate type *Salpingœca* almost invariably takes, as already described, a transverse direction, it appears in the compound pedicellate genus *Codosiga* to as constantly follow a longitudinal one, it being, indeed, this latter mode of fission, accompanied by the adherence to one another of the individual monads by their bases,

or to the common supporting stem, that the luxuriant colony-forms of this beautiful genus are produced. A single monad of *Codosiga pulcherrima* is shown at Plate III. fig. 10 in the act of dividing into two by this last-named characteristic mode of fission, and in which process it will be seen that the division extends to both the hyaline collar and the flagellum. These several processes of multiplication—by fission in a twofold manner and by the breaking up of the parent body, after encystment, into locomotive spores—are found to persist not only throughout this special collar-bearing group, but must now evidently be accepted as presenting the normal method of reproduction among all Protozoic structures. Preceding this more important mode of increase by the resolution of the parent body into spores, it frequently happens that two or more individuals coalesce or fuse intimately, mostly in an amœboid form, with one another, and produce one single capsular encystment. This process, however, does not appear in all cases to be essential. Taken as a whole, the representatives of the protozoic or unicellular animal sub-kingdom are thus shown to agree in their reproductive and developmental phenomena with the unicellular and other lower cryptogamic plants, and might therefore with equal justice be appropriately denominated cryptogamic animals. These two animal and vegetable groups again exhibit a further striking parallelism, inasmuch as neither in the former does a true egg, nor in the latter a true seed, constitute the essential reproductive product, as is the case with all of the more highly organized structures on either side. Among the developmental phenomena, supplementary to the foregoing, presented by the collar-bearing group here specially considered, that associated with the building up of the protective sheath of the loricated genus *Salpingœca* is well worthy of notice. This structure, as shown in the case of *S. ampulla* at Plate IV. figs. 13 and 14, takes its origin as a mere mucus-like excretion from the surface of the monad's body, and at a period prior even to the appearance of the collar. In a very short time after its excretion, the lorica acquires its normal consistency, and is then of considerable solidity, as is proved by its retention of its form for a considerable interval after the death of its original occupant.

Absorbing as the investigation of these minute independent collar-bearing monads is sure to become to any microscopist adopting the same as a subject for study, on the merit of their intrinsic beauty and variety of form alone, it has yet to be shown that they possess a still more interesting and important bearing with reference to their relationship or affinity with certain other animal organisms. Prof. H. James Clark, the authority already quoted as the first to report the occurrence within American waters of some three or four varieties of these

collar-bearing species, simultaneously announced his discovery that one of the calcareous-spiculed sponges (*Leucosolenia botryoides*, Bwbk.) consisted of aggregations of essentially similar collar-bearing monads, immersed within the structureless sarcode or spicule-producing element. This important discovery, confirmed by an examination of other species, Prof. Clark regarded as completely setting at rest the long-vexed question concerning the true nature and affinity of the sponges, and conclusively demonstrating the necessity of their recognition as colony-building flagellate infusorial forms. Professor Clark's decease shortly after this announcement, together with the novel theory concerning these same organisms that was brought forward at about the same date by Professor Ernst Hæckel, and in which it was sought to show that the sponges were referable to a far more highly organized animal group, served to almost entirely divert the attention of biologists from those views that originated with the first-named authority. Notwithstanding, however, this temporary diversion of scientific thought into a novel, and, at first sight, sufficiently plausible channel, the researches of recent investigators are tending to confirm the views of the American naturalist, almost all of these being unanimous in recognizing that the ciliated lining of the various-shaped sponge-cavities is essentially composed of collar-bearing flagellate cells similar to those just described as existing in *Leucosolenia botryoides*. Although thus admitted, however, by such authorities to constitute an important element in all sponge-structures, very few are at present inclined to concede to these collar-bearing flagellate cells the primary position assigned to them by Professor Clark. In accordance with the view of the former, indeed, each such flagellate collar-bearing cell is not to be regarded as a separate and independent monad or individual, but merely as a single cell-constituent of a continuous and epithelium-like internal lining membrane.

The above-mentioned opposing views held respecting the true nature and affinity of the sponges may thus at the present day be said to provide material for as fierce a controversy between leading scientific authorities as was maintained in similar circles during the first half of this century relative to the claims of these same organisms for admission into the ranks of the animal kingdom, and which has not for so very long a while been universally accorded them. If, as Prof. Hæckel and the advocates in whole or in part of his theory assert, sponges are composed of separate multicellular membranes or tissues, they undoubtedly find their nearest allies among the Cœlenterata, including the sea-anemones and hydroid zoophytes. If, on the other hand, as represented by Prof. Clark, they consist of aggregations of unicellular collar-bearing flagellate monads, their

place is unquestionably adjacent to the more simple unicellular Protozoa, including the ordinary monads, Rhizopoda, and Infusoria. The fuller light so much needed to determine once and for all this abstruse but exceedingly interesting question of the true nature and affinity of the sponges, has without doubt been considerably obscured through the absence, since the death of Prof. Clark, of all further testimony or corroborative evidence relative to those independent collar-bearing monad forms upon which his arguments were essentially based, and which, if his views were correct, might be expected on a closer and more extended acquaintanceship to yield parallel structural and developmental data of the greatest importance. This hiatus in the chain of evidence was early recognized by the writer, and may be said to have directly led to the investigations pursued in reference to this group within the past five or six years, resulting in the discovery of the innumerable previously unknown species, many of which are figured for the first time in these pages. Having this amount of material available for correlation and comparison, the case for the advocates of the protozoic nature of all sponges has been immeasurably strengthened, while little if any substantial foothold would seem to be now left for the adherents of the opposite or cœlenterate persuasion. Examining numbers of sponges and comparing the structure and manifestations of their collar-bearing unicellular constituents with those of the solitary or colony-forming individuals of the genera *Codosiga*, *Salpingœca*, and others previously referred to, the phenomena elicited were found to be altogether identical. Every separate collar-bearing cell in these sponge-structures was found in a similar manner to possess a separate and independent existence, capturing its food in the same manner with its exquisitely hyaline wineglass-shaped trap of circulating sarcode, possessing the same posteriorly situated and rhythmically opening and closing contractile vesicles, dividing by longitudinal or transverse fission, and ultimately encysting and breaking up into countless germs or spores destined to grow to individuals identical with the parent form, and further extend the borders of the commonwealth. In common with the independent collar-bearing types, these sponge-monads were found also to be possessed of an equal or even greater amount of plasticity of external form, retracting their characteristic collar and flagellum, and assuming an amœboid aspect in a manner closely identical with what has been already described of *Salpingœca amphoridium* and *fusiformis*. Often, again, these sponge monads (see Plate III. fig. 31), having the collar and flagellum withdrawn, throw out long, slender, capitate processes, which communicate to them an appearance closely resembling that of certain of the suctorial animalcules or *Acinetæ*.

That sponges, taken as a whole, possess a something over and above what is encountered in the simple, independent, collar-bearing monad types cannot for a moment be denied. What the distinction is, and the extent to which it complicates or masks their true nature and affinities, may be briefly explained. A sponge-body, cut through and examined with the microscope, though presenting at first sight an exceedingly complex type of structure, will be found on closer inspection to consist of a few very simple elements. Occupying, in the majority of species, the largest, but by no means most essential portion of its composition, is the glairy, gelatinous sarcode, or syncytium, which forms, as it were, the basis or superstructure in and upon which all the other elements are distributed. Within its substance are imbedded, or, in fact, originated, when present, the various skeletal components, whether spicules, horny fibre, or a combination of the two, that give to the complete sponge that amount of rigidity or variety of contour that distinguishes the various species. Abundantly scattered throughout the substance of this slimy matrix will likewise be found the amœbiform bodies of every shape and size to which the name of "cytoblasts" has been latterly applied. Last and most essential of all are the collar-bearing flagellate monads or spongozoa, identical in form and structure with the independent collar-bearing species already introduced. These constituent sponge-monads most usually either line the entire surface of the inner cavities of the sponge, or occupy special spherical chambers within the same. These three living elements or factors now enumerated, namely, the glairy and structureless syncytium, the amœbiform cytoblasts, and the collar-bearing, flagellate monads, once intelligently recognized, the reduction of the sponge-structure to a still more simple formula is, with the light now afforded by a knowledge of the structure and developmental history of the independent collar-bearing types, a comparatively easy task. With such accessory light it may be shown, indeed, that the collar-bearing monads are the *only* essential factors, and that towards them all the remaining structures occupy an entirely subordinate position. Given, in fact, a single one of these constituent monads, and a perfect sponge-body can in a little while be progressively built up. By a mucus-like exudation from its surface the basis of the syncytium is laid in a manner absolutely identical with the process by which the at first mucilaginous, but afterwards indurated lorica, or protective sheath of the genus *Salpingœca* is originated.* By a re-

* Several higher ciliate infusorial forms produce a mucilaginous investing sheath by a similar process of exudation. In one of the most conspicuous of these, *Ophrydium versatile*, large colony-masses are formed containing

peated process of cleavage or fissigemmation the original sponge-monad quickly multiplies itself, though still more rapidly and effectively by the subsequent encystment and breaking-up of the monad bodies into spores. In the independent collar-bearing types, as already shown, the germs or spores resulting from this process of encystment are discharged into the surrounding water, and thus dispersed to considerable distances. In the sponges, however, this act of encystment takes place within the substance of the syncytium, and within its substance are the spores released. In this element, moreover, they immediately find a most appropriate nidus or matrix for their future development, and are to be encountered on examination in every phase of transition. As it has been previously shown that the larval or initial conditions of the independent collar-bearing monads take the form of either amœbæ or simple flagellate monads, so also it will be found that the collar-bearing sponge-monads commence existence as similar simple units. Aided, indeed, by the light afforded by the developmental phenomena of this independent group it is easy to recognize that the amœbiform bodies of every variable shape and size dispersed among the syncytial element of the sponges are merely the larval or transitional conditions of the adult collar-bearing monads which they ultimately resemble. Between the amœbiform and the adult state there is usually also an intermediate stage, in which the sponge-monad, not having yet acquired the characteristic collar, possesses a single lash-like flagellum. An illustration of such intermediate flagellate types, taken from an example of a siliceous-spiculed sponge, *Halichondria panicea*, will be found represented at Plate III. fig. 32.

In addition to developing by fission, or as simple units or individuals, from the amœboid to the collar-bearing stage, and thus contributing to the further extension of the parent colony, it remains to be mentioned that in many, if not all, sponges there is another process of development attended with more complex phenomena, contributing to the production of detached and free-swimming monad-aggregations specially adapted to secure the wider distribution of the species. In this instance the amœbiform units, either as mature cytoblasts or as collar-bearing monads returned to an amœboid state, fuse or coalesce intimately with one another in variable numbers, producing by such an amalgamation an amœbiform body of considerable size. By a process of geometrical cleavage or multiple fission,

hundreds of separate individuals all enclosed within a common gelatinous investing sheath, and presenting a general aspect clearly resembling that of the fresh-water sponge, *Spongilla fluviatilis*, with which it is frequently associated.

this enlarged amœboid body now gives origin to a structure so closely resembling the "morula" that results from the primary segmentation of the ovum of all higher animals, that the nature of a true egg or ovum has been inaccurately attached to it by some authorities. By degrees each constituent segment of this moruloid body assumes a lengthened conical form, and, acquiring a terminal flagellum, presents in the aggregate the aspect given at Plate III. fig. 27.

Developing still further, this moruloid body finally, and in its most characteristic phase, exhibits the form shown at fig. 28 of the same plate, and in which condition it may be described as a spherical or ovoid aggregation, hollow within, of typical collar-bearing monads or spongozoa, individually identical with those of *Codosiga pulcherrima* or any of the independent collar-bearing types figured on the same plate. Floating away in this condition the collars and flagella of the sponge-monads are subsequently retracted, a syncytial exudation is thrown out as a veil around them, the spicules or other skeletal elements make their appearance in the same, and the body, attaching itself by some point of its periphery, usually the posterior one, speedily presents in miniature all the essential features of the parent sponge which gave it birth. The special collar-bearing cells now project into the interior cavity, opening externally by a single flue or osculum, and rapidly multiply by those various processes of fission or resolution into spores already described.

By those hitherto insisting on the recognition of sponges as animals qualified to rank with the Cœlenterata or lowest Metazoa rather than with simple unicellar Protozoa, the free-swimming compound gemmules just discussed have been seized upon as yielding the most conclusive evidence. The various arguments, however, brought forward in association with these structures in support of this cœlenterate view, have been considerably weakened since the first attempt made by Prof. Hæckel to establish for them a form and structure identical with his typical but hypothetical "Gastræa," or larval stockform of all animals higher than the Protozoa. This "Gastræa," consisting of a capsular body with a single terminal orifice and body-wall composed of two separate cellular membranes, an ectoderm and endoderm, was supposed to find its ideal personification in the compound ciliated sponge-gemmule. A more intimate and accurate acquaintance with these bodies has, however, revealed to numerous observers the entire untenability of this hypothesis. It is now definitely determined that there is no separation of the walls of the gemmule into an outer and inner cellular membrane or ectoderm, as originally premised, and no terminal orifice leading into the central cavity. The strongest, and apparently the only argument, indeed, that can now be brought forward in favour of the

affinity of the sponges with the Cœlenterata or other Metazoa, is the circumstance that these free-swimming gemmules are produced, as already notified, by a process of cleavage or segmentation resembling that usually regarded as the special property only of the true ovum of all higher animals, from the Cœlenterata upwards. Could no instance be adduced in which parallel phenomena occur among other undoubted Protozoa, this argument would carry with it considerable weight. It has, however, been recently shown by the valuable researches of Messrs. Dallinger and Drysdale that, among certain simple free-swimming monad forms, the coalescence of two or more individuals may give rise to a precisely similar process of cleavage or segmentation, terminating in a similar moruloid structure. The component segments of this pseudo-morula, however, are the equivalents, as in the case of the sponge-gemmule, of distinct individual zooids, and which in this instance become finally separated from one another and distributed through the surrounding water as uniflagellate monads.* It requires merely the permanent attachment in a colony-form of the individual units of Messrs. Dallinger and Drysdale's multiple-fission monad to produce a structure in all ways corresponding with the ciliated sponge-gemmule in its earliest stage, as shown at Plate III. fig. 27, and the addition to the same units in such an attached form of terminal hyaline collars, to typify the still more characteristic phase illustrated at fig. 28.

The close relationship which undoubtedly subsists between the sponges and the, as now shown, extensive group of independent collar-bearing Flagellate Protozoa represented in luxuriant variety in the accompanying plates, will scarcely be called in question by those who, first making themselves acquainted with the members of this last-named group, turn their attention to the physiology of the sponges. It is only, indeed, through such a preliminary acquaintance with the more simple independent forms that this intricate question of the nature and affinities of these more complicated aggregations of otherwise essentially similar units can be satisfactorily approached. While, therefore, recommending the newly-discovered group of independent collar-bearing Flagellate Protozoa to the attention of working microscopists, it is much to be desired that they shall supplement such observations as they may make in connection with the same by a practical examination of the structure of all such sponge forms in the living state to which they may have access. In either field our knowledge may be said as yet to extend no further than the threshold, and in each of the same there is pro-

* An illustration of this interesting type will be found in vol. xiv. Plate CXXIV., figs. 9 and 11, accompanying the article quoted in the footnote of page 115.

bably more original discovery waiting to be achieved than in any other group of the organic world. The forty or more specific types of the independent collar-bearing forms that have rewarded the writer's desultory investigations spread over some five or six brief years, may be safely accepted as representing but a very small instalment of the innumerable varieties that are doubtless awaiting a more thorough and systematic research; while of the sponges it may be said that we are as yet but imperfectly acquainted with the complete structural and developmental phenomena of even half a dozen out of the many hundred discovered species. In reference to these last-named organisms it is worthy of remark, before taking leave of them, that Professor H. James Clark, when first pointing out the intimate relationship between their essential living units and the two or three independent collar-bearing forms discovered by himself, hazarded the opinion that future investigation would probably reveal that different groups of sponges were composed of monads, corresponding in individual structure or presenting combinations of the various independent generic types; and this anticipation has been remarkably fulfilled in the case of one of the simplest known sponge forms recently discovered, and to which the name of *Gastrophysema primordialis* has been given by Professor Hæckel. A small fragment of this interesting variety with its characteristic internal lining of collar-bearing monads is shown at Plate III. fig. 38, and this type may be said to present an amalgamation of the generic characters of the two genera *Codosiga* and *Salpingœca*, certain of the monads being naked as in the former genus, and others enclosed within a flask-shaped lorica, as in the latter one. In the last-named instance the monad illustrated has entered into a quiescent or encysted condition within its lorica, presenting under such circumstances an aspect absolutely identical with the similar encysted condition of *Salpingœca amphoridium* shown at Plate IV. fig. 7. Professor Hæckel, unaided by an acquaintance with the independent collar-bearing forms here described and illustrated, and assuming for all sponges a cœlenterate type of organisation, has singularly associated with these flask-shaped loricæ and their encysted contents the structure and functions of rudimentary glandular organs.

Before leaving the microscopist to make his first essay in that new and fertile field for investigation to which his attention is now directed, a few hints as to the conditions under which the most complete success is likely to be achieved may prove acceptable. The first matter of importance is his apparatus; and here, should he not be in a position to command one of the highly perfected achromatic object glasses of our best English makers, let him be by no means discomfited. A German one-sixteenth

inch immersion lens, yielding a magnifying power of from 700 to 2,000 diameters and upwards, may be obtained at Mr. Charles Baker's, of 244 High Holborn, for the modest sum of 3*l*. Such an object-glass will be found equal to interpreting the form and structure of any of the numerous types figured in the accompanying plates, and with such a lens, indeed, the whole of these forms were, with but few exceptions, in the first place discovered and delineated by the writer.

The mechanical apparatus being decided on and obtained, it remains only to select the material for investigation. Either salt or fresh water will be found to yield its quota of the types required, and those frequenting the last-named element, being usually the more accessible, will most probably command first notice. Here the investigator will find his time most profitably employed in procuring from the nearest weedy pond or ditch a bottleful of the finely divided leaves of Myriophyllum, or of tangled confervoid growths, in either case selecting more especially those brown-hued specimens coloured by a dense incrustation of other more minute vegetable and animal parasitic growths. Care should likewise be taken to enclose with the water as large a number as possible of the specimens of *Cyclops* and other Entomostraca abundant in such situations, and to which will be frequently found attached species rarely, if ever, to be met with elsewhere. Patiently exploring every filamentous division of the above-mentioned weeds with the lower of the two powers employed, it will be scarcely possible to miss encountering one or more of the species illustrated in the accompanying plates. As first seen with this lower or reconnoitring power, it will of course be almost impossible to distinguish the characteristic collar, and the monads will appear as mere luminous specks adherent to the plants under examination. Meeting with these, the higher power must be brought into focus, when the true nature of the organisms will be revealed. Among the varieties which are likely at first to be encountered are, perhaps, the two loricated species *Salpingœca amphoridium* and *fusiformis* (See Plate IV. figs. 3 and 23), the former often completely incrusting several consecutive joints of various thread-like confervæ, while the latter will occur as solitary individuals scattered about at uncertain intervals. On the stronger fulcrum for support afforded by the leaf-partitions of Myriophyllum, the illoricate species *Codosiga pulcherrima* (Plate III. fig. 9) is often present in great profusion, its sociable pedicellate colonies being so thickly placed as to present the appearance of a perfect little forest of crystal-fruited trees. More rarely, under similar conditions, the extremely elegant and symmetrically tripartite branching pedicellate form *Codosiga umbellata* (Plate III. fig. 4) may be likewise met with.

At the outset, considerable difficulty will doubtless be experienced in the satisfactory definition of the hyaline collar characteristic of all the members of this group, a most careful manipulation of the light being often requisite to show this structure to advantage. It frequently happens again that when the entire contour of the wineglass-shaped collar is not to be distinguished, its presence is indicated by the clearer outline of its two lateral margins, which, standing out at an acute angle from the perpendicular line formed by the central flagellum, present the aspect of two additional hair-like processes. The appearance of this organ, when seen as described in the last sentence, is indicated at Plate IV. fig. 41, illustrative of the so-called "animalcule with ear-like processes," figured many years since by Mr. Carter, but which undoubtedly represents a species of *Salpingœca* with the characteristic collar indistinctly seen. In a similar manner other species now shown to belong to this newly discovered collar-bearing group have from time to time been imperfectly figured by various authorities, who, when encountering them, have not employed sufficient magnifying power or that mode of illumination requisite for the interpretation of their true character.

Having, with the assistance of these few hints, made himself familiar with but two or three only of the interesting types here introduced to his notice, the investigator will experience but little difficulty in extending the circle of his acquaintanceship with the same, and can scarcely fail before long to become so absorbed in admiration of the infinite variety of form and vital phenomena they present, as to regard as lost any further time bestowed on the markings of either Diatoms or Podura scales—*et hoc genus omne.*

EXPLANATION OF PLATES.

With one or two exceptions all the figures in the accompanying plates represent the objects delineated as seen with a magnifying power of from 500 to 2,000 diameters.

PLATE III.

Fig. 1, 2. Adult colonies of *Codosiga cymosa*, Sav. Kent.
„ 3. A single monad of the same species in an encysted state.
„ 4. Adult colony of *Codosiga umbellata*, S. K.
„ 5. Adult colony of *Codosiga alloides*, S. K.
„ 6. A single monad of the same with the body and collar retracted.
„ 7. Monad of the same species in its fully expanded state.
„ 8. Adult individual of the solitary form *Monosiga angustata*, S. K.
„ 9. Adult colony of *Codosiga pulcherrima*, J. Clk.

Fig. 10. A monad of the above dividing by longitudinal fission.

„ 11. A monad of the same species, with the collar and flagellum withdrawn, emitting pseudopodic processes.

„ 12. An encysted monad of the same species with the body broken up into spores.

„ 13. An adult colony of *Codosiga grossulariata*, S. K.

„ 14. An adult colony of *Codosiga pyriformis*, S. K.

„ 15. Single individual of *Monosiga brevipes*, S. K.

„ 16. *Monosiga globularis*, S. K., showing at *a* and *b* free-swimming and attached larval forms.

„ 17. Adult colony of *Codosiga candelabrum*, S. K.

„ 18. Single individual of *Monosiga gracilis*, S. K.

„ 19. Body of the same still further enlarged and diagrammatically illustrating the feeding process described at p. 117. The arrows indicate the direction of the current caused by the rotatory motion of the flagellum and the course taken by the food particles on striking against and adhering to the collar. *fl.* Flagellum. *c.* Collar. *n.* Nucleus. *f.* Food-particles. *cv.* Contractile vesicles.

„ 20. Free-floating colony of *Astrosiga disjuncta*, S. K.

„ 21. Four monads of *Monosiga consociatum*, S. K.: at *a* an individual in a quiescent or encysted state.

„ 22. An individual of the same species assuming an amœboid form and exhibiting extensive internal vacuolation.

„ 23. Adult free-floating colony of eight monads of *Desmarella moniliformis*, S. K.

„ 24. Colony of two individuals of *Codosiga furcata*, S. K.

„ 25. Animalcule figured by Stein as probably the young of *Opercularia nutans*, but probably identical with the above species.

„ 26. Abnormal colony-form of *Codosiga cymosa*, S. K.

„ 27. Free-swimming multiple-fission gemmule of a calcareous sponge, *Sycon ciliatum*, in diagrammatic longitudinal section.

„ 28. A more advanced stage of the above, in which the separate flagellate cells have acquired the characteristic collars of the adult sponge-monads.

„ 29. An adult sponge-monad of *Grantia compressa* in its normally expanded state. *n.* Nucleus. *cv.* Contractile vesicle.

„ 30. A collar-bearing monad from the same sponge emitting pseudopodic processes from its posterior extremity.

„ 31. A monad from the same sponge with the collar and flagellum withdrawn assuming an *Acineta*-phase.

„ 32. Initial or mono-flagellate larval condition of a siliceous sponge, *Halichondria*.

„ 33. Sporocysts of a siliceous sponge, *Halichondria*.

„ 34. Portion of syncytium of a calcareous sponge, *Leucosolenia botryoides*, having imbedded in its substance a sporocyst containing spores, and also free spores recently liberated from a similar cyst.

„ 35. Section through a monad-chamber or 'ampullaceous sac' with its contained collar-bearing monads, and portion of the syncytium of a siliceous sponge. *a.* Ampullaceous sac. *b.* Amœboid particles or cytoblasts.

Fig. 36. Sporocyst of a species of *Halichondria* bursting and liberating its contained spores.

„ 37. Sporocyst and liberated spores of another siliceous sponge.

„ 38. Fragment of the cavity-lining of *Gastrophysema dithalamium* (Hæckel), one of the simplest known sponge forms; showing two collar-bearing monads, two larval or amœboid cytoblasts, and a flask-shaped sporocyst, copied from Prof. Hæckel's illustrations of the species.

PLATE IV.

Fig. 1. Adult colony-form of *Polynœca dichotoma*, S. K.

„ 2. Colony of numerous individuals of *Salpingœca amphoridium*, J. Clk., attached to a confervoid filament.

„ 3. A single individual of the same species in its normal and fully expanded state.

„ 4. Monad with collar withdrawn but flagellum remaining, and protruding a portion of its body-sarcode from the orifice of its lorica.

„ 5. Monad with collar and flagellum withdrawn, and the body-sarcode protruded as lobate pseudopodic processes.

„ 6. The protruded portion of the above detached in the form of a minute stellate amœba.

„ 7. The quiescent or encysted condition of the same species.

„ 8. *Salpingœca inquillata*, S. K., larval form in the act of constructing its lorica.

„ 9. Adult individual of the same species.

„ 10. An individual of the same species multiplying by transverse fission.

„ 11. *Salpingœca ampulla*, S. K.

„ 12. Deserted lorica of the same species exhibiting fluted markings.

„ 13. An early phase of the same species in which the lorica is as yet only in a mucilaginous condition; the uniflagellate monad, marked *a*, adherent to the top left-hand corner of this sheath, is a larval form of the same species.

„ 14. The same larval form represented at 13*a*, commencing the construction of its lorica by a process of exudation.

„ 15. *Salpingœca cylindrica*, S. K.

„ 16. Sociable colony of *Salpingœca tuba*, S. K.

„ 17. Two monads of *Salpingœca gracilis*, J. Clk.

„ 18. *Salpingœca cornuta*, S. K., the monad adherent to its lorica posteriorly by three pseudopodic prolongations.

„ 19. Another monad of the same species adherent to its lorica by a single and elastic pedicelliform extension of its body substance.

„ 20. An individual of *Salpingœca gracilis*, J. Clk., dividing into two by transverse fission; at *a* the separated anterior half swimming off as a simple uniflagellate monad.

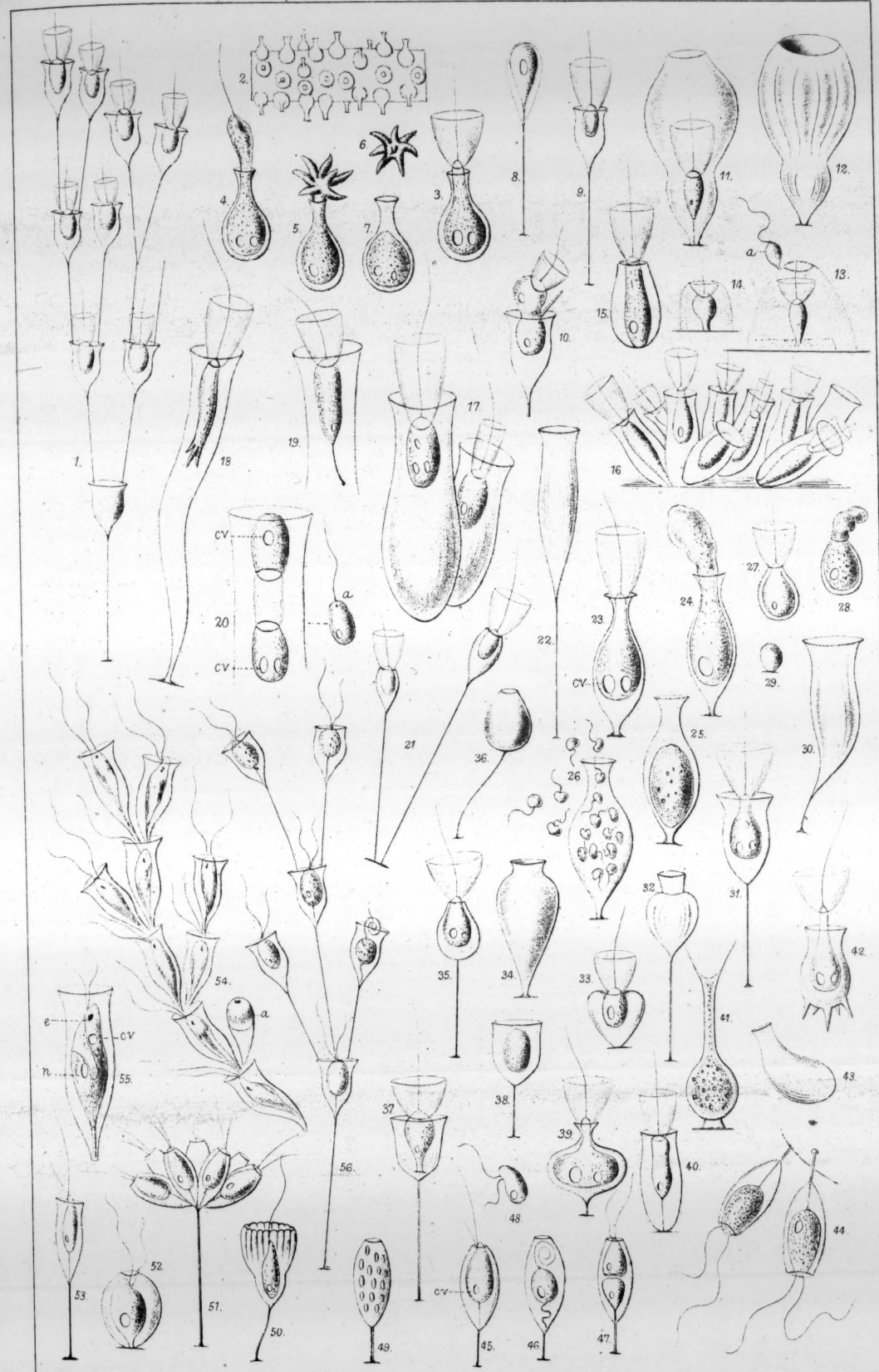
„ 21. Two individuals of *Salpingœca longipes*, S. K.

„ 22. Empty lorica of *Salpingœca teres*, S. K.

„ 23. *Salpingœca fusiformis*, S. K., in its normal and fully expanded state.

„ 24–26. Three developmental conditions of the same species illustrating respectively the amœboid, encysted, and sporuliferous phases.

FIG. 27, 28. *Salpingœca minuta*, S. K., in its normal and amœboid phases.
„ 29. Early or larval condition of the same species.
„ 30. Empty lorica of *Salpingœca curvipes*, S. K.
„ 31. *Salpingœca ringens*, S. K.
„ 32. *Salpingœca urceolata*, S. K.
„ 33. *Salpingœca pyxidium*, S. K.
„ 34. *Salpingœca amphora*, S. K.
„ 35, 36. *Salpingœca marina*, J. Clk.
„ 37. *Salpingœca tintinnabulum*, S. K.
„ 38. Encysted condition of the same species.
„ 39. *Salpingœca napiformis*, S. K.
„ 40. *Salpingœca petiolata*, S. K.
„ 41. *Salpingœca Carteri*, S. K.
„ 42. *Lagenella cuspidata*, S. K.
„ 43. *Salpingœca Wallichi*, S. K.
„ 44. Two individuals of *Bicosœca socialis*, S. K.
„ 45. *Bicosœca lacustris*, J. Clk. in its normally extended state.
„ 46. The same withdrawn within its lorica.
„ 47. The same species dividing by transverse fission.
„ 48. Free-swimming product of the above process of transverse fission.
„ 49. Spore-condition of *Bicosœca lacustris*.
„ 50. *Codonœca costata*, J. Clk.
„ 51 *Dinobryon epistyloides*, S. K.
„ 52. *Bicosœca bulla*, S. K.
„ 53. *Bicosœca gracilipes*, J. Clk.
„ 54. *Dinobryon sertularia*, (Ehr.), a compound colony of eleven individuals showing at *a* the method of gemmation.
„ 55. A single individual of the above further enlarged. *n*. Nucleus. *e*. Eyespeck. *cv*. Contractile vesicle.
„ 56. A compound colony of *Dinobryon petiolatum*, Duj.



W. Saville Kent del.

Mintern Bros lith.

Flagellate Protozoa.

THE CHINA CLAY INDUSTRY OF CORNWALL AND DEVON.

By J. H. COLLINS, F.G.S., Secretary of the Royal Institution of Cornwall.

TRAVELLERS by the Great Western Railway in the West of England, after crossing the great Albert Bridge at Saltash, passing over the tree tops in the deep valleys about Liskeard, and leaving the deserted copper mines of St. Blazey and Par on their right hand, usually observe truckloads of peculiar white substances occupying the sidings, and are especially struck with the whiteness of the streams crossed by the railway—which closely resemble rivers of milk.*

Naturally they begin to ask what it means, and the writer has often been amused by the gravity with which some fellow-traveller, who seems to think it disgraceful to confess ignorance on any subject whatever, vaguely talks of lime, or more boldly of chalk. Perhaps some native happens to be present, who politely assures him that he is in error—that neither chalk nor lime are present in any form—and that the peculiar whiteness is caused by a refuse product from the china-clay works in the vicinity. This of course settles the question usually; but if the original querist happens to be inquisitive or persistent, he soon finds that the native in most cases is entirely ignorant of the methods of working, the extent of the works, and the uses of the product, and if this is true of the intelligent native, still more is it true of the general public. Out of Cornwall it is a rare chance to find either commercial men, or even scientific geologists, who have any knowledge whatever of the peculiar industry which characterizes many parts of Cornwall and Devon, and especially the centre of Cornwall. Yet this industry is interesting in itself, employs a large number of men, and supplies every year more than 200,000 tons of the

* Notwithstanding the apparent opacity of the water from suspended particles of clay and mica, I have seen trout 8 or 9 inches long taken from these streams.

dazzling white clay, which never fails to attract the attention of tourists.

The object of the present paper is to describe the salient features of this industry. Most people know that "china" was first brought by the Portuguese from China—hence the name. It was called by them "porzellano," because it was supposed to be fabricated from sea shells: hence the term "porcelain;" but no real knowledge was obtained of the materials used until the publication of the reports of the Jesuit Father D'Entrecolles, in 1712, and of Count Réaumur, in 1729. These reports led to the establishment of the manufactories at Dresden, Sevres, and Plymouth—the last-named having been established in 1733. Up to 1745, the fine porcelain materials used in the Plymouth works were imported; but soon after that time, Mr. Cookworthy, the founder of the works, discovered "kaolin" (which he calls *growan clay*, now called *china clay*), and the "petuntze" (called by him *growan* or *moorstone*, and now known as *china stone*) similar to or identical with that used by the Chinese, in several parts of Cornwall in great abundance. In conjunction with Lord Camelford, he took out a patent for the use of these materials in 1768. How these materials are used in the manufacture of porcelain, earthenware, and more recently in many other British manufactures, forms no part of the subject of the present paper—this is limited to a description of the modes of occurrence and of preparation of the china clay and china stone.

China clay is prepared by washing a peculiarly white decomposed granite, which occurs very largely in the granite district, north of St. Austell, as well as in many other parts of Cornwall —and also in Devon. This natural china clay rock, which has been elsewhere called "Carclazyte," is simply a granite composed of white or pale smoky quartz, white mica (lepidolite), sometimes a little greenish-yellow gilbertite, and white felspar, *in which the latter is partly or completely metamorphosed into kaolin*. This modification of granite occurs in areas of irregular form, generally much elongated in one direction, and extending to an unknown depth. It is in the West of England universally associated with quartzose and schorlaceous veins—evidently of later origin than the rock itself—which sometimes also contain oxide of tin. The greatest extension of the decomposed granite coincides with the "run" or "bearing" of the veins, and is more complete as the vein is followed downwards in depth.*

* In a paper read before the Royal Geological Society of Cornwall in 1876, I have given my reasons for believing that the decomposition has been produced *in situ* by fluids circulating within the fissures, joints, and shrinkage

Many of the so-called "deposits" of clay extend for a distance of a quarter of a mile, half-a-mile, or even more, in the direction of the veins, while their breadth may be only a few inches, and seldom exceeds a few fathoms. It is true that very wide masses of china clay are wrought in many places, but these are invariably associated with a group of parallel veins.

The granite rock is usually covered by a layer, from 4 to 30 feet thick, of brown or yellow sandy earth, often full of angular pieces of hard granite, schorl rock, tourmaline schist, with sometimes a little tin ore, &c. This layer is called by the workmen "overburden," and it must be removed before the clay can be got at.* The process of working is usually as follows:—Let us suppose that a patch or band of suitable decomposed granite, called by the workmen a "bed of clay," has been discovered in a hill-side. The first thing to be done is to drive an "adit-level" horizontally right into the hill beneath the bed of clay, the position and extent of which has been more or less accurately determined by systematic "pitting" through the overburden. This adit-level is a sort of tunnel—from 6 to 9 feet high, and from 3 to 6 feet wide. While this level is being driven, a large piece of the overburden is removed so as to expose a considerable area of the bed of clay.† A vertical opening or shaft is then made from the inner end of the adit, to the surface of the uncovered clay bed—partly by digging downwards from above ("sinking"), partly by digging upwards from below, ("putting up a rise"). A square wooden pipe, having holes at regular distances of a few feet in one of its sides, is then placed in the vertical opening, so as to keep open a communication with the level below;‡ the remainder of the shaft is then either filled in or kept open for the removal of the coarse sand or stones produced in working; and the regular washing of clay may be proceeded with. Of course the arrangements for obtaining the clay vary very much in different works. These different

cracks of the granite—now occupied by the solid matter of the veins referred to above—and not as commonly stated in geological works by carbonic acid acting from above.

* This covering closely resembles some glacial deposits; but neither organic remains, nor scratched stones, nor stones of foreign origin have been found in it, to my knowledge, although many acres have been removed in the various clay works.

† The term "clay" is applied indiscriminately in Cornwall to the decomposed granite rock, and to the true clay washed out of it.

‡ The holes are—except the top one—temporarily covered with pieces of board nailed over them. The whole contrivance is called a "button-hole launder."

arrangements were described by the author in the 'Journal of the Society of Arts,' 1875.

Granite, as is generally known, consists mainly of three distinct minerals, quartz, felspar, and mica. In the decomposed granite it is the felspar only which is decomposed, or converted into kaolin; but this renders the whole mass so soft that a pick or shovel may be readily driven into it to a considerable depth. The mode of working is to break up a portion with a pick to a depth of several feet, in a kind of slope, around the mouth of the pipe or launder which passes down into the adit below. This is called a "stope." A stream of water is then made to flow over the broken lumps, which are kept well stirred up by a workman, called a "washer," whose duty it is to keep breaking and stirring them up. The water, clear at first, speedily becomes white and milky by washing out the soft decomposed felspar, and runs down to the bottom of the stope, carrying with it the quartz grains and flakes of mica. The quartz and the coarser mica flakes, called "sand" by the workmen, settle in a shallow pit, called the sandpit, from whence they are constantly shovelled out by a man placed there for that purpose—while the stream of clay water, carrying with it many minute flakes of white mica, passes on down the vertical launder and through the adit-level to be further treated.

The stream of clay water, if thick, contains usually about 2 per cent. of clay, and perhaps one-half per cent. of mica in suspension. This is made to flow slowly through a succession of narrow channels, called "drags" and "micas," in which the fine mica and a little clay are gradually deposited, while the bulk of the clay passes on with the water, and falls into a circular pit from twenty to thirty feet in diameter, and eight or ten feet deep, lined usually with granite blocks. Here it gradually settles to the bottom, while the clear water passes off at a little depression in the rim of the pit, and may either be pumped up to be used over again, or allowed to flow into the nearest river. This effluent water is often clear enough to drink.*

Once or twice a day it becomes necessary to clean out the long channels, called "drags" and "micas," in which case the fine mica and clay, which has settled at the bottom, is washed out into the nearest watercourse by a stream of water, and this it is which fouls the streams.

In some works, as at the celebrated Carclaze Mine, worked

* Occasionally these pits are left filled with clay water, and undisturbed for several weeks, when the intense blueness of the water equals that of some Alpine lakes, and is due to the same cause—the suspension of minute particles of solid matter.

as an open quarry for tin for four centuries, not only is the mica washed away in this manner, but the large quantity of sand produced is also washed away at night, and thus very large accumulations of sand have collected in the valleys below St. Austell, St. Blazey, and elsewhere.

The clay having settled in the pits to a consistency somewhat thicker than cream, is in old-fashioned works run out into shallow excavations called "pans." These are about two feet deep—the clay is put into them during the winter months, and is allowed to remain until nearly dry, when it is cut out in square blocks and piled up under sheds, or in the open air, till completely dry. By this mode of working a good deal of loss is experienced, as every block of clay is more or less injured at the surface by exposure for months to the vicissitudes of the weather, the invasions of sheep, cattle, and geese—which latter abound on the moors—and the mischief of stone-throwing boys. When thoroughly dry, therefore, every block has to be separately scraped before it is in a fit state to be sold.

The scraping operation is a peculiar and somewhat ghastly sight to those who see it for the first time. Gangs of tall women, white-aproned—every vestige of complexion hidden with white clay—stand at tables scraping the blocks all day long, with a little three-cornered scraper like a miniature Dutch hoe, and often dismally singing hymns which sound like dirges.

The advantage of air-drying is that no expense is incurred for fuel—the disadvantage is the loss incurred by scraping, the expense of scraping, and the large area required for the drying pans.

In more modern works the air-drying is mostly replaced by kiln-drying. Long kilns are built of fire-clay tiles covering brickwork flues from 60 to 100 or even 150 feet long. The clay from the circular pits is first run into large tanks, where it remains for a month or two, till pretty stiff. It is then taken into the kiln or "dry" on tramwaggons, and dried by throwing it upon the hot tiles. When dry it is cut up into convenient sized blocks and piled up ready for market. On the whole, the smaller amount of waste in kiln-dried clay, and the saving of expense for scraping, more than makes up for the expense of fuel, and few modern works are without kilns for drying.

The preparation of the china stone for the market is a much more simple operation. China stone is also a kind of granite, which is, however, only partially decomposed, but it is only valuable when it happens to be free from mica and all other minerals except the quartz and partially decomposed felspar. It occurs chiefly in the parishes of St. Stephens, St. Dennis, and Breage, and is often associated with china clay. The rock is simply quarried down, and the joints dressed over where discoloured

with oxide of iron, when it is at once ready for shipment, chiefly to Runcorn. From Runcorn it is sent to the potteries, where it is used with china clay in the manufacture of porcelain and earthenware.

It is not only in the potteries, however, that china clay is used. As stated above, more than 200,000 tons per annum are now exported from the two western counties, the value of which at the present exceptionally low prices may average, perhaps, 1*l.* per ton at the shipping port. Of this large quantity probably little more than one-third is used in the English potteries. Fully as much is used by the paper-makers of the United Kingdom, and probably 20,000 tons are used by makers of alum and sulphate of alumina, and at least as much by "bleachers" of calico and yarn. Many thousands of tons are shipped to the Continent for all the above purposes, and also for the manufacture of ultramarine. So cheap and convenient an article is also no doubt used to a considerable extent by adulterators and sophisticators of various kinds, but it probably only needs to be more widely known to be used legitimately for many purposes to which hitherto it has not been applied.

We have spoken above of the "sand" of the "mica." Nowadays much of the fine mica is re-washed and sold as an inferior "mica clay" for making inferior kinds of paper and pasteboard, but the bulk of it must still be regarded as a waste product. The sand is also largely a waste product, and as there are from three to eight tons of sand yielded for each ton of clay, large accumulations exist at most of the principal works. Of late years some of this—mixed with refuse clay—has been made into excellent fire bricks, for which there is a considerable demand, especially for the copper-smelting furnaces of Chili and Mexico; but there are still millions of tons available when a proper use can be discovered.

Very good building bricks have also been made from the discoloured clay and mica, but the heavy cost of carriage usually prevents the use of building bricks at great distances from the place of manufacture, so that, although there is a fair local demand, millions of tons of material are still available for any suitable purpose which may be hereafter discovered.

Some of the sand is very coarse, some very fine—but in all cases it consists mainly of angular fragments of quartz, admirably adapted from their extreme sharpness for mixing with cement or lime for making concrete blocks, or with asphalt for pavements.

The coarser varieties also make excellent gravel walks, as the small quantities of clay and mica usually present serve to bind the grains together under foot to form a firm roadway.

The following analyses, selected from the writer's paper read

to the Royal Geological Society of Cornwall in 1876, fairly represent the composition of average specimens of the materials described above.

	China Clay	China Stone	Mica Clay	Coarse Mica	Sand
Silica	45·40	71·66	46·70	56·41	81·50
Alumina	40·30	18·79	35·20	29.60	13·40
Lime	trace	1·70	trace	—	—
Magnesia	trace	0·35	—	—	—
Peroxide of iron . .	0·20	trace	1·90	2·72	2·50
Alkalies, insoluble and loss	0·60	6·60*	4·66	4·37	0·10
Fluorine	trace	0·14	trace	trace	trace
Oxide of manganese . .	—	trace	—	trace	—
Water	13·50	0·91	11·54	6·90	2·50
	100·00	100·15	100·00	100·00	100·00

All the older writers speak of "Talc," "Talcose granite," "Protogine," &c., as being abundant in Cornwall and elsewhere. Even Mr. J. A. Phillips, writing in 1875, says: "In some districts mica is replaced by a talc-like mineral, and the granite rock itself passes into protogine." What there may be elsewhere I am unable to say, but there is certainly nothing of the kind known at present in Cornwall. From the whole of the granite districts of Cornwall and Devon talc seems to be entirely absent, and magnesia generally is an extremely scarce substance.

The number of china clay works at present in operation in Cornwall and West Devon is little short of 200, and of course the conditions of working vary considerably in different localities and under different conditions. In some, a little washing only is done during the winter months by means of a small natural stream of water, the total annual produce being only a few hundred tons; in others, valuable machinery and extensive buildings enable the proprietors to turn out nine or ten thousand tons in the same time; but in the main the description given above as fairly describes the occurrence and preparation of china clay and china stone as is possible within the limits of such an article as the present.

The trade at present is much depressed—mainly, I believe, owing to the slackness on the part of those (potters, paper-makers, bleachers, and others) who use clay; but partly, perhaps, owing to the over-production of a few years since. In consequence of this the prices have fallen more than 30 per cent. during the last five years, and the quantities produced have also shown a

* Chiefly potash.

considerable falling off. With the general revival of English trade—whenever that may take place—no doubt this branch will also revive.*

* The following table—compiled from Mr. Hunt's Mineral Statistics—shows the variations of production (in tons) since the year 1874, when the largest quantities were produced:—

	China Clay		China Stone	Total
	Cornwall	Devon		
1874 . . .	150,500	33,309	42,500	226,309
1875 . . .	108,250	29,146	38,000	175,396
1876 . . .	105,275	25,000	34,500	164,775
1877 (estimated) .	100,000	22,000	30,000	152,000

THE EXTINCT BRITISH WOLF.

By J. E. HARTING, F.L.S., F.Z.S.

(*Continued from* p. 61.)

PERIOD from the Conquest to the reign of Henry VII.—Historical evidence of the existence of wolves in Great Britain before the Norman Conquest, as might be expected, is meagre and unsatisfactory, and the abundance of these animals in our islands prior to that date is chiefly to be inferred from the measures which in later times were devised for their destruction.

The *Carmen de Bello Hastingensi* (v. 571) states that William the Conqueror left the dead bodies of the English upon the battlefield to be devoured by worms, wolves, birds, and dogs —*vermibus, atque lupis, avibus, canibusque voranda.*

In 1076 Robert de Umfraville,* Knight, lord of Toures and Tain, otherwise called "Robert with the beard," being kinsman to that king, obtained from him a grant of the lordship, valley, and forest of Riddesdale, in the county of Northumberland, with all castles, manors, lands, woods, pastures, waters, pools, and royal franchises which were formerly possessed by Mildred, the son of Akman, late lord of Riddesdale, and which came to that king upon his conquest of England; to hold by the service of defending that part of the country for ever from enemies *and wolves*, with the sword which King William had by his side when he entered Northumberland.†

1087–1100. The inveterate love of the chase possessed by William Rufus, which prompted him to enforce, during his tragical reign, the most stringent and cruel forest laws, is too well known to readers of history to require comment. It can-

* "The name seems to be derived from one of the several places in Normandy now called Amfreville, but in some instances originally Omfreville, that is *Humfredi villa*, the vill or abode of Humphrey."—Lower, "Patronymica Britannica."

† See Dugdale's "Baronage," vol. i. p. 504, and Blount's "Ancient Tenures," p. 241.

not be doubted that in the vast forests* which then covered the greater part of the country, and through which he continuously hunted, he must have encountered and slain many a wolf. Yet, strange to say, a careful search through a great number of volumes has resulted in a failure to discover any evidence upon this point, or indeed any mention of the wolf in connection with this monarch.

Longstaffe, in his account of "Durham before the Conquest," states that a great increase of wolves took place in Richmondshire during this century, and mentions incidentally that Richard Ingeniator dealing with property at Wolviston (called Olveston in the time of William Rufus) sealed the grant with an impression of a wolf.

1100–1135. In his passion for hunting wild animals, Henry I. excelled even his brother William, and not content with encountering and slaying those which, like the wolf and the wild boar, were at that time indigenous to this country, he "cherished of set purpose sundrie kinds of wild beasts, as bears, libards, ounces, lions, at Woodstocke and one or two other places in England, which he walled about with hard stone An. 1120, and where he would often fight with some one of them hand to hand." †

1156. There can be no doubt that at this period, and for some time afterwards, the New Forest as well as the Forest of Bere, in Hampshire, both favourite hunting grounds with William Rufus and his brother Henry, were the strongholds of the wolf, as they were of the wild boar and the red deer, for in the second year of the reign of Henry II. the Sheriff of Hants had an allowance made to him in the Exchequer for several sums by him disbursed for the livery of the King's *wolf-hunters*, hawkers, falconers, and other things. "*Et in liberatione lupariorum* 100*s.*, *et in liberatione accipitrariorum et falconariorum Regis* 22*li. per Willelmum Cumin.*" ‡

In the fourth year of the same reign, the Sheriffs of London were allowed by the Chancellor 40*s.* out of the Exchequer for the King's huntsmen and his dogs. "*Et venatoribus Regis et canibus ejus* xl^{s} *per cancellarium.*" §

* "The word 'forest,' in its original and most extended sense, implied a tract of land lying out (*foras*), that is, rejected, as of no value, in the first distribution of property."—Whitaker, "History of Whalley," p. 193.

† Harrison's Description of England, prefixed to Holinshed's "Chronicle," p. 226.

‡ Madox, "History and Antiquities of the Exchequer of the Kings of England from the Norman Conquest to the end of the Reign of Edward II.," vol. i. p. 204 (1769).

§ Madox, tom. cit. p. 207.

Conan, Duke of Brittany and Earl of Richmond, in 1164, granted, amongst other privileges, to the Abbey of Jourvaulx, several pastures on the north side of the river Jore, reserving only liberty for his deer, likewise pasturage throughout his new forest, near Richmond, Yorkshire, for all their cattle, with power to keep hounds for chasing wolves out of those their territories.*

In 1167, the Bishopric of Hereford was vested in the King in consequence of the see being then vacant; and in the account of John Cumin, who acted in the capacity of Custos, we find in the accounts of the revenue and expenditure of the temporalities a payment of 10*s.* for three wolves captured that year. "*Et pro tribus Lupis capiendis, x*^{s}."

William Beriwere obtained from Henry II. the confirmation of all his lands, as also the forestership of the Forest of De la Bere, with power to take any person transgressing therein between the bars of Hampton and the gates of Winchester, and likewise between the river of Ramsey and the river of Winchester to the sea, as amply as his father had held the same in the times of King William and King Henry I. From Richard I. (whom he accompanied to the Holy Land, and whom he was instrumental in delivering from prison when that King was confined in Germany) he obtained many valuable emoluments as well as large territorial grants, and in the following reign was no less fortunate with King John, who, having a great regard for him in consequence of his knowledge in the art and mysteries of venery, gave him license to enclose his woods at Joare, Cadelegh, Raddon, Ailesberie, and Burgh Walter, with free liberty to hunt the hare, fox, cat, and *wolf*, throughout all Devonshire, and likewise the goat beyond the precincts of the forest; and to have free warren throughout all his own lands for hares, pheasants, and partridges. †

From a charter of liberties granted by King John, when Earl of Morton, to the inhabitants of Devonshire, it appears that the wolf was at that time included amongst the "beasts of venery" in that county. The original deed, which is still preserved in the custody of the Dean and Chapter of Exeter, is under seal, and provides *inter alia* as follows:—"*Quod habeant canes suos et alias libertates, sicut melius et liberius illas habuerunt tempore ejusd. Henrici regis et reisellos suos, et quod capiant capreolum, vulpem, cattum, lupum, leporem, lutram, ubicunque illa invenirent extra regardum forestæ meæ.*" ‡

* Dugdale's "Baronage," vol. i. p. 48. Ex Regist. Archiep. Cant. p. 875*a*.

† Dugdale's "Baronage," vol. i. p. 701; Curt. Antry. H. n. 16.

‡ Ex Autographo penes Dec. et. Capit. Exon. From Bp. Lyttelton's Collections. Quoted by Pennant, "British Zoology," vol. ii. p. 308 (1812).

1209. Mr. Evelyn P. Shirley has printed * two deeds of the 10th of John relating to the manor of Henwick, in the parish of Bulwick, county Northampton, held by the tenure of hunting the wolf (*fugaco'm lupi*), and he suggests that from this tenure probably the family of Luvet or Lovett, originally of Rushton, and afterwards of Astwell, in the county of Northampton, bore for their arms: Argent, three wolves passant in pale sable, armed and langued gules.†

1212. In this year, when the neighbourhood around Kingsclere was all forest, we find an entry in the Patent Rolls of a payment of 5*s*. as a reward for the capture of a wolf at Freemantle.‡

Amongst the entries in the *Rotulus Misæ, anni Regis Johannis quartodecimi* (1212–1213), are the following, which relate to the capture or chase of the wolf:—

"On Thursday next in the octave of the Holy Trinity [May 12], for a wolf captured at Freemantle [Surrey] by the dogs of Master Ernald de Auclent, 5*s*."

"*Item*. [at Hereford]. Thursday next following the Feast of St. Martin [Nov. 22] to Norman the keeper of the Veltrarš,§ and to Wilkin Dogget, his associate, for two wolves captured in the forest of Irwell, 10*s*., by the King's command, &c."

"*Item*. Wednesday next following the feast of St. Gregory [March 12], for two wolves captured, one at Boscha de Furchiis, the other at Willes, 10*s*., given to Smalobbe and Wilck, the keepers of the veltrariõ of Thomas de Sanford."

It is perhaps not generally known that the circumstance narrated in the story of Bedd Gêlert, with which every one is familiar, is said to have occurred in the reign of King John, and, as it is a story of a British wolf, it is scarcely to be passed over here without some brief notice, the more so as it is not at all unlikely that it is founded on fact.

The tradition, as related by Bingley in his "Tour round North Wales," ‖ is to the effect that Llewellyn, who was Prince of Wales in the reign of King John, resided at the foot of Snowdon, and, amongst a number of other hounds which he possessed, had one of rare excellence which had been given to him by the King. On one occasion, during the absence of the

* "Collectanea Topographica et Genealogica," vol. vi. p. 299.

† The wolf frequently appears on heraldic bearings, as we shall have occasion to notice more particularly later on.

‡ Patent Rolls, May 31, 1212, quoted in "Sussex Archæological Collections," xxiv. p. 161.

§ *Veltrarius*, or *vautrarius*, from the French *vaultre*, was a mongrel hound for the chase of the wild boar. Blount, "Ancient Tenures," p. 233.

‖ "A Tour round North Wales," 1800, vol. i. p. 363.

family, a wolf entered the house; and Llewellyn, who first returned, was met at the door by his favourite dog, who came out, covered with blood, to greet his master. The prince, alarmed, ran into the house, to find his child's cradle overturned, and the ground flowing with blood. In a moment of terror, imagining that the dog had killed the child, he plunged his sword into his body, and laid him dead on the spot. But, on turning up the cradle, he found his boy alive and sleeping by the side of the dead wolf. This circumstance had such an effect on the mind of the prince, that he erected a tomb over the faithful dog's grave on the spot where afterwards the parish church was built, called from this incident Bedd Gêlert, or the grave of Gêlert. From this story was derived the common Welsh proverb, "I repent as much as the man who slew his greyhound."

The dog referred to belonged probably to the race called by Pennant "the Highland gre-hound," of great size and strength, deep-chested, and covered with long rough hair. This kind was much esteemed in former days, and was used for hunting by all the great chieftains in preference to any other. Boethius styles it "*genus venaticum cum celerrimum tum audacissimum.*"

1216–1272. In the following reign of Henry III. wolves were still sufficiently numerous in some parts of the country to induce the King to make grants of land to various individuals upon the express condition of their taking measures to destroy these animals wherever they could be found.

In 1242 it appears that Vitalis Engaine made partition with William de Cantelupe, Baron of Bergavenny, of the manor of Badmundesfield, in Suffolk, as heir to William de Curtenai, and the same year had a summons, amongst divers great men, to attend the King, well appointed with horse and arms, in his expedition into France. He died in 1249, seized, *inter alia*, of part of the lordships of Laxton and Pichesle, in the county of Northampton, held by "petit serjeanty," viz. to hunt the wolf whensoever the King should command.*

Selden, in his notes to Drayton's "Polyolbion" (ix. 76), refers to the manor of Piddlesey in Leicestershire, which was held by one Henry of Angage *per serjeantiam capiendi lupos*, and quotes as his authority Itin. Leicester. 27 Hen. III. in Archiv. Turr. Lond. In the same reign, William de Limeres held of the King *in capite*, in the county of Southampton, one carucate of land in Comelessend by the service of hunting the wolf with the King's dogs.†

* Dugdale's "Baronage," vol. i. p. 466.

† Esc. temp. H. R. fil. R. Johannis. Harl. MS. Brit. Mus. No. 708, p. 8.

1272–1307. In the third year of the reign of Edward I., namely in 1275, Sir John d'Engayne, knight, and Elena d'Engayne, his wife, held lands in Pightesley, in the county of Northampton, by the service of hunting the wolf, *for his pleasure*, in that county,* from which it is to be inferred that this animal was then common enough to be hunted for sport, as the fox is now-a-days. Other lands in the same county were held at this time on condition of the tenant finding dogs "for the destruction of wolves" and other animals.† It appears by the Patent Rolls of the 9th year of Edward I. that in 1280 John Giffard of Brymmesfield or Brampfield, was empowered to destroy the wolves in all the King's forests throughout the realm.‡

In 1281, Peter Corbet was commissioned to destroy all the wolves he could find in the counties of Gloucester, Worcester, Hereford, Salop, and Stafford, and the bailiffs in the several counties were directed to be ready and assist him. The commission, which has been frequently referred to by different writers, runs as follows:—

"*Pro Petro Corbet, de lupis capiendis.*

"Rex, omnibus Ballivis, &c. Sciatis quod injunximus dilecto et fideli nostro Petro Corbet quod in omnibus forestis et parcis et aliis locis intra comitatus nostros Gloucester, Wygorn, Hereford, Salop, et Stafford, in quibus *lupi* poterunt inveniri, *lupos* cum hominibus, canibus et ingeniis suis capiat et destruat modis omnibus quibus viderit expedire.

"Et ideo vobis mandamus quod idem intendentes et auxiliantes estis.

"Teste rege apud Westm. 14 Maii A.D. 1281." §

In 1285 William de Reynes held two carucates of land at Boyton, in the parish of Finchingfield, in the county of Essex, by the serjeanty of keeping for the King five wolfdogs (*canes luporarios*).‖ In the following year John Engaine was returned as holding one carucate of land in Great Gidding, in the county of Huntingdon, by the serjeanty of hunting the wolf, fox, and wild cat, and driving away all vermin out of the forest of the King in that county.¶ About the same time Richard Engaine

* Plac. Coron. 3 Edw. I. Rot. 20, *dorso*. Blount, "Ancient Tenures," p. 230.

† Camden, "Britannia," p. 525, and Blount, p. 257.

‡ Calend. Rot. Pat. 49. See also Rymer's "Fœdera," *sub anno*.

§ Cf. Rymer's "Fœdera," i. pt. 2, p. 192; ii. p. 168.

‖ Plac. Coron. 13 Edw. I. Essex; Blount, "Ancient Tenures," p. 236.

¶ Plac. Coron. 14 Edw. I. Rot. 7, *dorso*; Blount, p. 230.

held one hundred shillings of land in the town of Guedding, in the county of Cambridge, by the serjeanty of taking wolves, and he was to do this service *daily* (*et facit servic' suum cotidie*),* from which it may be inferred that wolves at this date were particularly troublesome.

In 1297 John Engaine died, seized, *inter alia*, of certain lands in Pytesle, Northampton, found to be held of the King by the service of hunting the wolf, fox [cat], badger [wild boar, and hare]; and likewise the manor of Great Gidding in Com, Huntendon, held by the service of catching the hare, fox, cat, and wolf within the counties of Huntendon, Northampton, Buckingham, and Roteland.†

In the accounts of Bolton Priory, quoted in Whitaker's "History of Craven" (p. 331) occur entries in the years 1306–1307, of payments made in reward for the slaughter of wolves, as "*Cuidam qui occidit lupum*," but the price paid to the slayer is not stated.

1307–1327. In the fourth year of Edward II. (1311) a composition was made between Sir John de Mowbray, son and heir of Sir Roger de Mowbray, of the one part, and the Abbot of Selby of the other part, whereby the said Sir John quitclaimed and released to the Abbot all his right in the soil and manor of Crowle and other places therein mentioned, and the Abbot and convent granted to the said Sir John de Mowbray certain woods, saving their free warren of goats, foxes, wolves, conies, &c.‡

The King's forest of the Peak in Derbyshire was of great extent, and about this time was much infested with wolves. A family of the hereditary name of Wolfhunt held lands by the service of keeping the forest clear of these destructive animals.§ From the records in the Tower of London (13 Edw. II.) it appears that in 1320 some persons held lands at Wormhill, in the county of Derby, by the service of hunting and taking wolves, from whence they were called Wolfhunt or Wolvehunt.

Mr. W. H. G. Bagshawe, of Ford Hall, Chapel-en-le-Frith, Derbyshire, a descendant of the same family as Mr. F. W. Bagshawe, the present owner of Wormhill Hall, in reply to

* Testa de Nevil, p. 358; Blount, p. 262.

† Dugdale's "Baronage," vol. i. p. 466. See also the *Rotuli Hundredorum*, ii. p. 627.

‡ Burton, "Monasticon Eboracense," p. 389. The Abbots of Selby and of St. Mary, at York, were the only two mitred abbots in Yorkshire.

§ "The Local Laws, Courts, and Customs of Derbyshire," Journ. Brit. Archæol. Assoc. vol. vii. p. 197.

inquiries on the subject, has been good enough to write as follows:—

"With the particulars in Blount's 'Tenures' I have long been familiar, but I am sorry to say that I cannot add to them. Wormhill Hall was never, so far as I know, held under the tenure of destroying wolves, but it is most probable that a portion of the lands there were originally held by the tenure of preserving the King's 'verte and venyson' in his forest of the Peak.

"There is a tradition that the last wolf in England was killed at Wormhill, but I never saw any evidence of it, nor did I ever hear any date assigned.

"In my pedigree of our family I find a note to the effect that John de l'Hall (the ancestor of John de l'Hall whose daughter Alice was the wife of Nicholas Bagshawe) was appointed a forester (of fee, I suppose) to the King by deed dated 1349."*

1327–1377. So far as can be gathered from history, it would seem that while stringent measures were being devised for the destruction of wolves in all or most of the inhabited districts which they frequented, in the less populous and more remote parts of the country steps were taken by such of the principal landowners as were fond of hunting to secure their own participation in the sport of finding and killing them.

In Edward III.'s time, Conan, Duke of Brittany, in 1342, gave pasture for cattle through all his new forest at Richmond in Yorkshire to the inmates of the Abbey of Fors in Wensleydale, forbidding them to use any mastiffs to drive the wolves from their pastures.†

In the same year, Alan, Earl of Brittany, gave them common of pasture through all his forest of Wandesley-dale; and to cut as much grass for hay as they might have occasion for, and also gave them leave to take such materials out of the said forest to build their houses, and for other uses; and such iron and lead as the monks found they might apply to their own use; and if the monks or their servants found any flesh of wild beasts in the forest, *killed by wolves*, they might take it to their own use.‡

In 1348, we find that Alan, son and heir of Walter de Wulfhunte, paid a fine to the King of 2*s.* 4*d.* for his relief in respect

* Camden, "Britannia," tit. Derbyshire, i. p. 591; Blount, "Ancient Tenures," p. 250.

† Escheat, 15 & 16 Edw. III. no. 76, in Turr. Lond. See also Burton, "Monasticon Eboracense," p. 370. The Abbey of Fors, in Wensleydale, was founded in 1145 (Whitaker).

‡ Burton, loc. cit.

of lands at Mansfield Woodhouse, in the county of Nottingham, which he held by the service of hunting wolves out of the forest of Shirewood, if he should find any of them.*

Thomas Engaine, dying without issue in 1368, was found to be seized of 14 yardlands and meadow, and 14*s.* 4*d.* rent, in Pightesle, in the county of Northampton, held by the service of finding, at his own proper costs, certain dogs for the destruction of wolves, foxes, martens, cats, and other vermin within the counties of Northampton, Roteland, Oxford, Essex, and Buckingham.†

Passing over the reign of Richard II. (1377–1399), during which we have not met with any particular mention of wolves in England, we come to that of Henry IV.

1399–1413. In this reign Sir Thomas de Aylesbury, knight, and Catharine his wife, held of the King, *in capite*, the manor of Laxton, *inter alia*, with the appurtenances in the county of Northampton, by "grand serjeanty"—viz., by the service of taking wolves, foxes, wild cats, and other vermin in the counties of Northampton, Rutland, Oxford, Essex, Huntingdon, and Buckingham.‡

Shakespeare has pictured wolves as existing in Kent in the time of Henry VI. When the Duke of Suffolk lands at night upon the shore near Dover, he hears

> "Loud howling wolves arouse the jades
> That drag the tragic melancholy night."
>
> 2 Hen. VI. act. iv. sc. 1.

This may or may not be a poetic license. At all events, no evidence on the subject is now forthcoming, and we must turn, therefore, to some more reliable source of information.

1422–1461. In the eleventh year of Henry VI. (1433), Sir Robert Plumpton, knight, was seized of one bovate of land in Mansfield Woodhouse, in the county of Nottingham, called Wolf-hunt land, held by the service of winding a horn and chasing or frightening the wolves in the forest of Shirewood.§ This tenure is particularly referred to by the Rev. Samuel Pegge in his paper "On the Horn as a Charter or Instrument of Conveyance."‖ A coloured plate of an ancient horn of the kind re-

* De termino Trin. anno 21 Edw. III. Rot. 1. Harl. MS. Brit. Mus. No. 34, p. 166. Blount, "Ancient Tenures," p. 258.

† Rot. fin. 42 Edw. III. m. 13. Dugdale's "Baronage," vol. i. p. 467; and Blount, "Ancient Tenures," p. 231.

‡ Blount, op. cit. p. 260.

§ Escaet. 11 Hen. VI. n. 5. Blount, p. 312.

‖ "Archæologia," vol. iii. p. 3. See also Thoroton, "Antiq. Nottingham." p. 273, and Strutt, "Sports and Pastimes," p. 19.

ferred to, in the possession of the late Lord Ribblesdale, will be found in Whitaker's "History and Antiquities of the Deanery of Craven" (1805), p. 34.

In the seventeenth year of the reign of Henry VI., namely, in 1439, Robert Umfraville, a descendant, no doubt, of the Robert de Umfraville mentioned in 1076, held the castle of Herbotell and manor of Otterburn, of the King, *in capite*, by the service of keeping the valley and liberty of Riddesdale, where the said castle and manor are situated, free from wolves and robbers.*

1461–1483. If no particular mention of wolves is to be met with in the days of Edward IV., his reign would nevertheless deserve mention here from the fact that at this period lived Juliana Barnes, or Berners, a lady of an ancient and illustrious house, who was commonly styled the Diana of her age, and writ divers treatises on Hunting, Hawking, Fishing, and Heraldry.†

In her "Boke of St. Albans," 1480, she includes the wolf amongst the beasts of venery, and thus instructs her readers on the subject:—

> "My dere sones wher ye fare by frith or by fell
> Take gode hede in hys tyme how Tristram ‡ will tell
> Four maner Bestes of Venery there are:
> The first of hem is a Hart, the second is an Hare,
> The Boor is one of tho,
> The Wolf and no mo."

1485–1509. Some time between these two dates, during the reign of Henry VII., it is probable that the wolf became finally extirpated in England, although for nearly two centuries later, as will presently appear, it continued to hold out against its persecutors in Scotland and Ireland. That it was rare if not quite extinct in England about this time, may be inferred from the circumstance that little or no mention is made of it either in this or any subsequent reign. We are aware that Professor Newton, in his "Zoology of Ancient Europe," has stated (p. 24) that the wolf was found in the North of England in the reign of Henry VIII., a statement which has been also advanced or copied by other writers,§ but we have not met with any proof of this. Indeed, Professor Newton has lately been good enough to inform us that he has forgotten his authority for the state-

* Madox, "Baronia Anglica," p. 244.

† Longstaffe, "Memoirs of the Life of Ambrose Barnes" (Surtees Society), 1867, p. 27.

‡ Manwood, in his "Forest Laws," mentions "Sir Tristram, an ancient forester, in his worthy treatise of hunting."

§ Wise's "New Forest, its History and its Scenery," p. 14.

ment and thinks it possible a reference to the MS. of his essay, which was not preserved, would show that, by a typographical error, the numerals VIII. were printed for VII.

In Longstaffe's "Memoirs of the Life of Ambrose Barnes," * it is stated that "his immediate ancestors held an estate of 500*l.* a year of the Earls of Rutland and Belvoir, one of whom (a Barnes of Hatford near Barnard Castle) was commonly called Ambrose 'Roast Wolf,' from the many wolves which he hunted down and destroyed in the time of Henry VII." †

In a footnote to this passage, the editor remarks that "the statement must be taken *cum grano salis*. Belvoir is not a title, and the Manners family did not become Earls of Rutland until 1525, in the reign of Henry VIII.‡ On the other hand, the period of Henry VII. is late for wolves, although Richmondshire might well yield some of the latest specimens in England. Doubtless they were familiarly associated with wildness of country long after their extinction. Many a tradition would linger in the families of their destroyers. Ambrose 'Roast Wolf' was probably a real person of some date or other."

Within the precincts of Savernake Forest, the property of the Marquis of Ailesbury, near Marlborough, there is still existing a very old barn and part of a house, known as "Wolf Hall." It was the ancient residence of the Seymours, and when Henry VIII. married Lady Jane Seymour it was here that he came a-courting, here that Queen Jane Seymour was married, and in this barn the wedding festivities are said to have taken place. In reply to our inquiry whether any tradition exists in the county to explain the name "Wolf Hall," the Rev. A. C. Smith, of Yatesbury Rectory, Calne, has obligingly written as follows:—"It is supposed by some to have had nothing to do with the animal 'wolf,' but rather with 'Ulf,' the owner's name, if there was such a person, and in the Domesday record it is spelt 'Ulfhall.' At the same time I must add that Leland in his Itinerary (ix. 36) calls it in Latin '*Lupinum villa splendida*,' and again in his poem on the birth of the Prince of Wales, afterwards King Edward VI.,§ '*Incoluit villam, quæ nomine dicta Lupinum.*' Bishop Turner also (Bibl. Brit.

* "Memoirs of the Life of Mr. Ambrose Barnes, late Merchant and sometime Alderman of Newcastle-upon-Tyne," p. 28. (Surtees Society, 1867.)

† See also Longstaffe's "Durham before the Conquest," p. 49.

‡ It is possible that a typographical error may have been made here also, and that Ambrose "Roast Wolf" may have lived in the reign of Henry VIII., not Henry VII.

§ Leland, "Genethliacon illustrissimi Eduardi Principis Cambriæ," &c., 1543.

Hibern.) speaks of certain epistles written by Edward, the future Protector, son of John Seymour, '*de Puteo Lupino, vulgo Wolf-hall.*' So I am not so certain that the derivation is not from the animal. At all events, it is quite clear that no place could be more fitted for wolves than the wild extensive forest of Savernake hard by: indeed, if wolves existed at all in England now, that would be just the very harbour for them."

Many names of places compounded with "wolf" still remain to attest probably the former existence of this animal in the neighbourhood. Wolmer, *i.e.* Wolfmere or Wolvemere, is an instance of this. Wolferton is another. Reginaldus, in the twelfth century, variously translates Wolsingham into the dwelling of Ulsus, the habitation of a wolf, and the howling of a wolf, expressed in the English tongue. So Symeon has "*Ulfswelle, id est fons lupi.*" *

Wolfenden in Rossendale, and Wolfstones in Cliviger (Lancashire), both attest the existence of this animal there when those names were imposed.† Many other instances, no doubt, might be adduced. In the parish of Beckermont, Cumberland, is a small hill, commonly called "Wotobank." A traditionary story, of great antiquity, says that a lord of Beckermont and his lady and servants were one time hunting the wolf; during the chase this lord missed his lady; after a long and painful search, they at last, to his inexpressible sorrow, found her body lying on this hill or bank, slain by a wolf, and the ravenous beast in the very act of tearing it to pieces, till frightened by the dogs. In the first transports of his grief the first words that he uttered were "Woe to this bank!" since which time it has been commonly called "Wotobank." ‡

In Lancashire, Dr. Whitaker particularly mentions the great forests of Blackburnshire and Bowland as "among the last retreats of the wolf." §

The "wolds" of Yorkshire appear, from the dates of parish books, to have been infested with wolves perhaps later than any other part of England.

"In the entries at Flixton, Hackston, and Folkston, in the

* Longstaffe, "Durham before the Conquest," p. 49.

† Whitaker, "History of Whalley," i. p. 74. "The first mention of Rossendale by name is in the memorable story of Liwlphus, dean of Whalley, who, at a place called Ledmesgreve, cut off the tail of a wolf in hunting" (tom. cit. p. 316).

‡ Hutchinson, "Hist. and Antiq. Cumberland," (1794) vol. ii. p. 16. Upon this tradition was founded an "elegant elegiac tale" by Mrs. Cowley, which will be found prefixed to the second volume of the work quoted.

§ Op. cit. i. p. 205. The last herd of red deer was destroyed there in 1805.

East Riding of Yorkshire," says Blaine, "are still to be seen memoranda of payments made for the destruction of wolves at a certain rate per head. They used to breed in the 'cars' below, amongst the rushes, furze, and bogs, and in the night time to come up from their dens; and, unless the sheep had been previously driven into the town, or the shepherds were indefatigably vigilant, great numbers were sure to be destroyed." *

Apparently, however, some error has been made in the orthography of the localities referred to. Flixton is in the parish of Folkton, near Scarboro'. We cannot find that there is any such place as Hackston, but Staxton adjoins the other places named, and is in the parish of Willerby. The Vicar of Willerby, the Rev. G. Day, at our request has most obligingly instituted a search, but has not succeeded in finding any parish-books of any kind to throw light on the subject. He writes: "There are no gentry resident in this parish, and the churchwardens have been tenant-farmers for generations. Of course great changes have occurred within the last, say, fifty years, amongst these tenant-farmers. Many names have altogether disappeared from the parish roll, and it is thought probable by some of the old farmers here that churchwardens in past days having left their farms and gone to other parishes took the parish books with them, and that these have either been destroyed or are lying hid in some descendant's lumber-room."

In a paper "On Druidical Remains in the Parish of Halifax, Yorkshire," by the Rev. John Watson, M.A., F.S.A.,† the author says that "in the township of Barkisland is a small ring of stones, now called (1771) by the name of the *wolf-fold*. It is but a few yards in diameter, but the exact measurement of it I have lost or mislaid.

"The stones of which it consists are not erect, but lie in a confused heap like the ruins of a building. This place I took at first, from its name, to have been either a decoy for the taking of wolves, or a place to secure them in for the purpose of hunting; but observing that Mr. Borlase (p. 198) has attributed some such little cirques to the Druids, I have mentioned it here for the further examination of antiquaries, who are desired to take notice that if ever there was a wall here of any strength, the best stones must have been carried away; for what are left are extremely rude, and totally unfit of themselves to compose any sort of building; also that these few insignificant pebbles, as they now appear, must be of considerable antiquity, as well as once have been of considerable account, because they give

* Blaine's 'Encyclop. Rural Sports' (1858), p. 105.

† Archæologia, vol. ii. p. 355.

the name of Ringstone Edge to a large tract of land around them."

The late Wm. Hamper, F.S.A., in some learned observations on certain ancient pillars of memorial called Hoar Stones (Archæologia, xxv.), gives a list of such as were known to him, and, in particular, mentions (p. 53) the *wolf-stone*, a single merestone, one immense natural block on Dr. Whitaker's estate, which, in all probability, was erected to commemorate some notable slaughter of wolves in days gone by.

[*To be continued.*]

THE LIQUEFACTION AND SOLIDIFICATION OF AIR AND HYDROGEN.

By W. N. HARTLEY, F.R.S.E., King's College, London.

IN a former article in the "Popular Science Review" (April 1877), it was found necessary to give a sketch of the researches of Faraday and others on the liquefaction of gases; and of Cagniard de la Tour and of Professor Andrews on the liquid and gaseous conditions of matter. According to the investigations of those observers a gas is nothing more than a highly attenuated vapour, and therefore capable of liquefaction. As, however, the hitherto possible deviations from the atmospheric temperature and pressure are insufficient to cause a change of state in many of these bodies, they have received the name of permanent gases. The distinction between a gas and a vapour is purely arbitrary. Ether in the gaseous state is called a vapour, while sulphurous acid is called a gas. They are, however, both the vapours of liquids which boil at + 35° C. (95° F.) and −10° C. (14° F) respectively.

In a recent article in the "Chemical News" M. Raoul Pictet has very concisely stated the conditions to be fulfilled before we may hope to bring the molecules of a gas into such close contact with each other that they may cohere to form a liquid:—

1. The gas must be absolutely pure, with no trace of a foreign gas.

2. A means of obtaining enormous pressures must be available.

3. A means of producing intense cold and subtracting heat at these low temperatures.

4. The utilization of a large surface for condensation at these low temperatures.

5. A means of utilizing the rapid expansion of the gas from extreme condensation to the atmospheric pressure—an expansion which, added to the preceding means, will *compel* liquefaction.

"Having fulfilled these five conditions, we may formulate the following alternative:—When a gas is compressed to 500 or

600 atmospheres, and kept at a temperature of — 100° C. or —140° C. (— 148° F. — 220° F.), and it is allowed to expand to the atmospheric pressure, one of two things takes place: either the gas, obeying the force of cohesion, liquefies, and yields its heat of condensation to the portion of the gas which expands and loses itself in the gaseous form; or, on the hypothesis that cohesion is not a general law, the gas must pass to the absolute zero and become inert; that is to say, an impalpable powder. The work done by expansion will not be possible, and the loss of heat will be absolute."

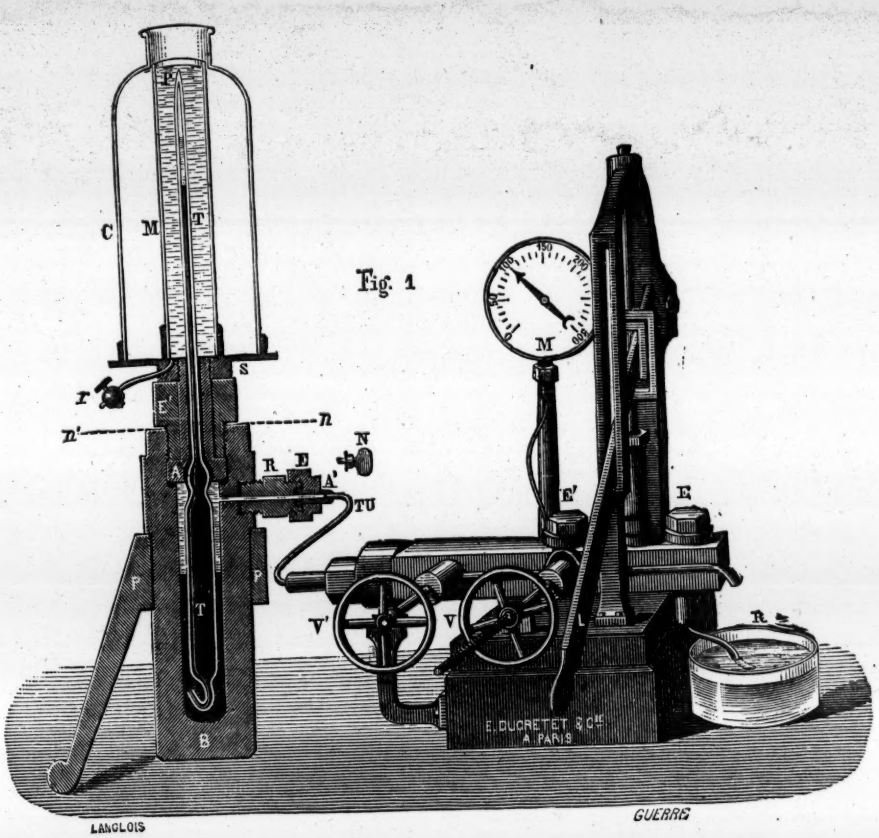
Struck with the truth of this alternative, which is rendered certain by thermo-dynamic equations, based upon accurate data, M. Pictet devised a mechanical arrangement which entirely satisfies these various conditions, and which has been the means of experimentally demonstrating the fact that molecular *cohesion* is a general property of bodies, to which there is no exception. While M. Pictet, of Geneva, has been engaged for more than three years with the solution of this problem, M. Cailletet, of Châtillon-sur-Seine, has devised an apparatus for the same purpose. This very beautiful instrument of M. Cailletet has been the first to compel the liquefaction of a so-called permanent gas, viz., nitric oxide. There soon followed a simultaneous liquefaction of oxygen by both experimenters. While, however, M. Cailletet obtains a visible indication of liquefaction with his instrument, M. Pictet produces a stream of liquid which may be submitted to examination.

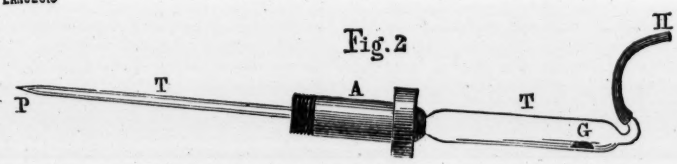
M. Cailletet's Apparatus.—There are two forms of this instrument both the same in principle, the large one in use at Châtillon-sur-Seine; and a smaller and very portable apparatus, constructed by M. Ducretet, of Paris, of which fig. 1 is a representation.

The gas to be compressed is contained in the glass tube (T T), the lower end of which is plunged into mercury, contained in the cistern (B), which is constructed by boring out a block of wrought iron so as to leave it as a cylinder with very thick walls. The lower point of the glass tube is curved, and in the bend a little mercury is placed, to keep out atmospheric air and prevent the escape of any gas before the tube is fixed in its place. The upper part of (T) is visible, and is surrounded by a jacket (M), containing a refrigerating liquid, such as liquid sulphurous acid, liquid nitrous oxide, or even iced water. Around the jacket (M) is placed a bell-jar (C), which contains some desiccating material, such as oil of vitriol or chloride of calcium, to dry the air, and so prevent the formation of a dew or deposition of hoar-frost on the glass. Should the tube break, these surrounding vessels would prevent any dangerous result. The compression in this instrument is obtained by hydraulic power, while

in the larger one in use at Châtillon-sur-Seine it is effected by a screw press.

The lever (L) when put in action is capable of giving a pressure of about 300 atmospheres, as indicated by the manometer (M). In order to increase this pressure the flywheel (V) is used, which acts upon a lateral screw plunger, capable of giving a pressure





A PORTABLE FORM OF CAILLETET'S APPARATUS FOR THE LIQUEFACTION OF GASES. SCALE $\frac{1}{8}$. (From "La Nature.")

of 500 atmospheres. The second flywheel (V′) serves to relieve the pressure with rapidity and cause a sudden expansion, a means whereby a lowering of the temperature of the gas contained in the tube may be effected to an extent of 200° C. (360° F.). This is the main advantage and peculiarity of M. Cailletet's instrument.

The tube (T T) is shown in fig. 2, detached from the cistern, for the purpose of being filled with the gas to be experimented upon. The apparatus for producing the gas is attached to the

tube (H); it escapes at the point (P), which of course is open. When the air has been completely expelled the point of the tube is sealed by a blowpipe, and the globule of mercury is made to occupy the curved end of the tube by simply raising the opposite extremity. The tube filled with gas is then detached, the more capacious portion is immersed in the cistern of mercury, fixed in position by a screw, and submitted to pressure. It is the water from the hydraulic pump contained in (R) acting on the surface of mercury in the cistern, which produces the latter effect. Pressures are indicated by the manometer (M′).

The Liquefaction of Oxygen. — On December 16 last M. Cailletet gave experimental evidence of the liquefaction of oxygen at the École Normale, in Paris. At a temperature of −29° C. (−20° F.), and under a pressure of 270 atmospheres, it was still in the gaseous state; but under the influence of a sudden expansion, which lowers the temperature about 200° C. (360° F.), a sort of mist is produced within the tube, which can be caused only by the oxygen being cooled below its critical point, and thus assuming the liquid state.

Nitrogen.—Pure dry nitrogen, compressed to about 200 atmospheres, at a temperature of + 13° C. (56° F.), if allowed to expand rapidly, condenses in a more complete manner; it first presents an appearance like that of spray, consisting of drops of an appreciable size, which move from the sides to the centre of the tube, forming a vertical column along its axis. The duration of this appearance is about three seconds.

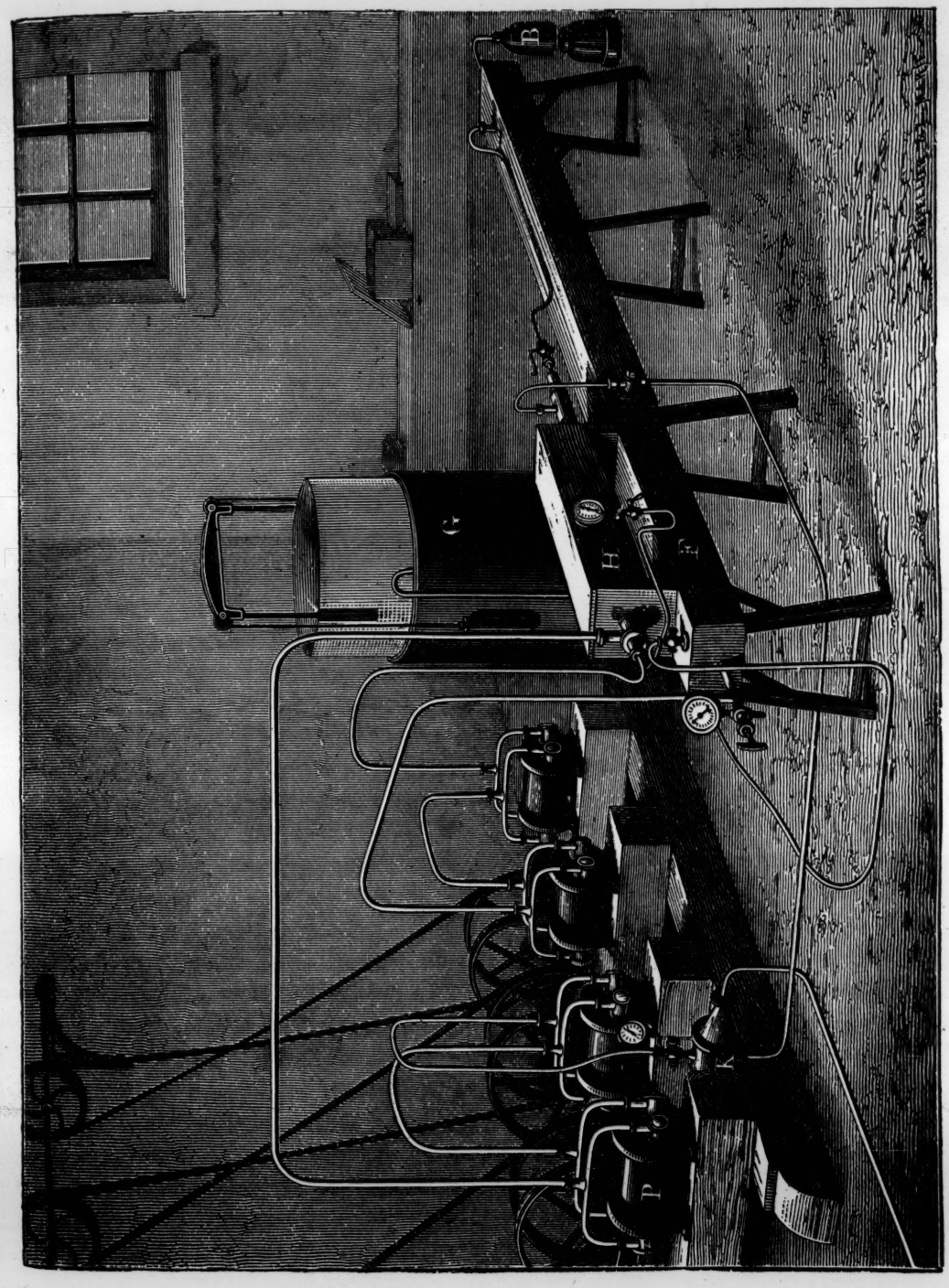
The experiment was repeated on December 30, in the presence of many *savants*, at the laboratory of the École Normale.

Hydrogen.—This substance, which possesses very nearly all the properties of a perfect gas, has been considered by most philosophers as absolutely incondensable. M. Cailletet, in submitting it to the tests which proved so successful with other bodies, failed on several occasions to observe any resulting phenomena. Several repetitions of his experiments on Dec. 31, in presence of MM. Ste. Claire Deville, Berthelot, and Mascart, gave indications of the liquefaction of hydrogen which were convincing to those who witnessed them. Pure hydrogen, under a pressure of 280 atmospheres, when allowed to expand very suddenly, forms an extremely attenuated mist, which instantly disappears. The production of this mist, notwithstanding its extreme subtlety, was regarded as an undoubted proof that a change to the liquid state had been effected.

Air.—By the liquefaction of oxygen and nitrogen that of air is already demonstrated; but as it was of interest to actually perform the experiment, a portion of air, dried and freed from carbonic acid, was submitted to pressure and subsequent ex-

pansion, and its condensation succeeded as might have been expected.

FIG. 3.

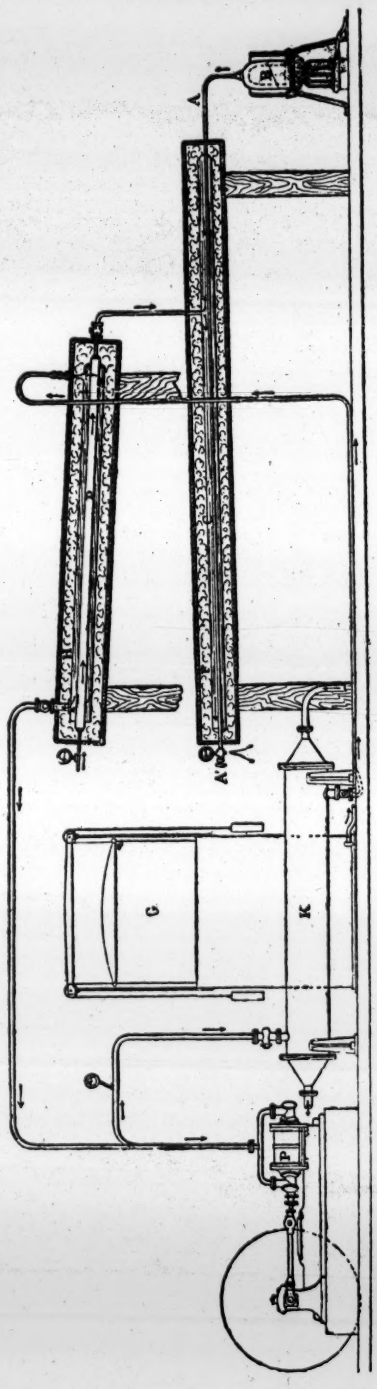


M. RAOUL PICTET'S MACHINE FOR THE LIQUEFACTION OF GASES. (From "La Nature.")

M. Pictet's Machine.—In a former number of the "Popular Science Review" (July 1877) the beautiful freezing-machine of

M. Raoul Pictet was described, and its advantages mentioned. It will be remembered that intense cold is produced in this machine by the evaporation *in vacuo* of sulphurous acid liquefied by pressure. In continuation, as it were, of this subject comes the following description of the most perfect and elaborate refrigerating apparatus, capable of withstanding enormous pressures, which has hitherto been constructed. It is the invention of M. Pictet, and is a further development of his ice-machine.

FIG. 4.



PLAN IN SECTION OF THE SAME.

The accompanying drawings (figs. 3 and 4), show the general arrangement of its parts, while some idea of its very considerable dimensions may be gained from the fact that the manometer near the letter (H) is raised from the ground about the height of a man, while the room is capable of holding more than thirty persons.

A howitzer shell (B), containing 700 grammes (a pound and a half) of chlorate of potash, mixed with chloride of potassium to moderate its decomposition. It is heated with gas.

(AA′, fig. 4.) A tube, over 16 feet in length, $\frac{1}{2}$ inch external diameter, and $\frac{1}{8}$ inch internal diameter, in which the oxygen condenses. It is furnished with a screw-tap at A′, from which the liquefied gas streams forth. A pressure-gauge measures the pressure up to 800 atmospheres.

(C) A tube, 13 feet in length, in which is solid carbonic acid. The stock of carbonic acid is contained in a gasholder (G), 220 gallons in capacity. A three-way tap places it, when desired, in connection with the apparatus.

(F) A non-conducting covering, with a wooden casing.

(D) A tube of $2\frac{1}{2}$ inches diameter, and 3 feet 7 inches long,

containing liquid carbonic acid, compressed by the pumps, and surrounded by liquid sulphurous acid, contained in a tube 5 inches in diameter and 3 feet 7 inches long.

(H) A non-conductor of heat, with a wooden covering.

(K) A tubular condenser for liquid sulphurous acid, compressed by the pumps.

(P) Double-action exhaustion and force pumps; two for drawing carbonic acid either from the tubular condenser or from the gas-holder, according to the position of a three-way cock; the other pair for exhausting sulphurous acid from the tube surrounding D.

The following is a concise description of the working of the apparatus:—A pair of pumps such as are used in the freezing-machine are so coupled that the exhaustion of one corresponds to the compression of the other. The exhaustion of the first pump communicates with the tube enclosed in (H), which contains liquid sulphurous acid. Under the influence of a good vacuum the temperature of this liquid rapidly sinks to −65° C. (−85° F.), or even to −73° (−100° F.), the lowest limit attained. Through this tube of sulphurous acid passes a second smaller one, in which is retained compressed carbonic acid. The carbonic acid, made from hydrochloric acid and Carrara marble, is washed and dried and stored over oil in a gas-holder.

At a pressure of six atmospheres the carbonic acid liquefies under these circumstances. The resulting liquid is passed into the long copper tube (C) (fig. 4).

A pair of pumps are arranged to exhaust carbonic acid either from this tube (C), or from the gas-holder (G). When the carbonic acid vapour is extracted from the tube in which it is contained the liquid solidifies, and its temperature descends to −140° C. (−220° F.). The subtraction of heat is maintained by the working of the pumps, the cylinders of which extract 3 litres, or approaching $\frac{3}{4}$ gallon, per stroke, at a speed of 100 strokes per minute. Both the cooling tubes are covered with a non-conducting material and a casing of wood. Through the interior of the carbonic acid tube passes the long tube (A), proceeding from the iron shell or retort: it is over 16 feet in length, with a base of about $\frac{1}{8}$ inch, and walls $\frac{3}{8}$ inch in thickness. Being constantly immersed in solid carbonic acid, the whole surface of the tube is brought to a temperature of −140° C. (−220° F.). The tube is slightly inclined, to allow of liquid collecting at the lower end. The upper end of the tube is curved, and screwed into the howitzer shell (B). The sides of this shell are more than 2 inches in thickness; its height is 18 inches, and its diameter 10 inches.

When oxygen is to be liquefied this shell contains $1\frac{1}{2}$ lbs. of

chlorate of potash and half a pound of chloride of potassium, mixed together, fused, broken up, and placed in the shell perfectly dry. When the double circulation of the sulphurous and carbonic acids has sufficiently lowered the temperature of the apparatus the shell is heated by a series of gas-burners. The disengagement of oxygen takes place at first gradually, and then rather suddenly, near the end of the operation. A pressure-gauge at the end of the tube gives constant indications of the progress of the reaction. The gauge, which is graduated to 800 atmospheres, was made expressly for M. Pictet by Bourdon, of Paris.

At the termination of the reaction the gauge indicates a pressure of 500 atmospheres, which almost immediately sinks and remains at 320 atmospheres. On opening the screw-tap a jet of liquid oxygen is seen to squirt out with extreme violence.

Pieces of charcoal, feebly incandescent, placed in the way of this jet inflame with inconceivable violence. A ray of electric light thrown upon the jet shows it to consist of two parts, one central, and an inch or so in length, the whiteness of which is suggestive of its being the liquid; the external portion has a blue tint indicating that it is probably a congealed mist.

Hydrogen.—On January 10 of the present year M. Pictet succeeded in liquefying, and even solidifying, hydrogen in the laboratories of the Society for the Construction of Physical Instruments, at Geneva.

The experiment was performed in the presence of several persons with great success.

The gas was obtained by the process of Berthelot, which yields it in a state of the most perfect purity. The reaction employed consists in decomposing formiate of potassium with caustic potash. At a pressure of 650 atmospheres and a temperature of −140° C. (−220° F.) there was emitted from the jet when the tap was opened a steel-blue jet, producing a hissing sound like that of a red-hot iron being immersed in water.

The jet suddenly became intermittent, and there succeeded a hail of solid particles, like small shot being projected on to the ground with violence. Their fall produced a harsh, shrill noise or crackling sound.

The tap was closed, and the pressure fell from 370 to 320 atmospheres, at which it remained some minutes. It then rose to 325 atmospheres. On opening the tap a second time only an intermittent jet escaped, rendering it probable that solidification had taken place within the tube. Proof of this was afforded by the fact that when the temperature was allowed to rise by stopping the pumps the escape of hydrogen in the liquid state was resumed.

M. Pictet has recently found, both by calculation and experiment, that liquid oxygen is identical in density with water.

But a few short months since and to have talked of being able to solidify hydrogen would have been idle; to have believed it impossible of accomplishment would have been deemed philosophical.

THE RADIOMETER.

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WITH the exception of the telephone, no discovery has for many years attracted so much public attention, both in scientific and in general circles, as the radiometer. Nor is this remarkable, if it be considered how perfectly novel and how striking were the phenomena which it for the first time brought to light. A new mine of knowledge seemed to have been opened, and it was matter of speculation as to what further treasures might thus be within our grasp. The crude facts of attraction, repulsion, and rotation were so unexpected, and yet so perfectly obvious, even to unpractised observers, that there is little cause for surprise at the warmth with which their explanation was attempted, and as little at the wildness and conflicting character of many suggestions that were offered. Light, heat, electricity, evaporation and condensation, the molecular constitution of gases, and even less probable hypotheses, all offered specious and plausible modes of accounting for what was an objective reality past denying. There was not even room for incredulity as to the fact; the less, in that the apparatus employed, consisting of a glass tube, a bar of common pith, and an ordinary candle, was so extremely simple. The machine, if indeed it was worthy of that name, went naturally into the category of those apparently trivial but really complex and pregnant combinations of common materials which, when once constructed, have each of them formed a beacon and signal post on the great high road of scientific discovery. That this was actually the attitude of the scientific mind may be seen from the words used by the President of the Royal Society in presenting the gold medal to the discoverer of the radiometer. "It is the mystery," said Dr. Hooker, "attending this phenomenon that gives it its great importance. There is evidently some action going on with which we are not at present acquainted; and there is no saying what a thorough investigation into the cause of the phenomenon may lead to."

It is perhaps not too much to say that in this instrument we have one of the grandest and purest demonstrations of the perpetual movement, the ceaseless flux and reflux, which is eternally going on in nature; an idea stated by the Greek philosopher in the axiom ῥεῖ πάντα, reappearing in the vortices of Descartes, and of late testified to by many and various experimental acquisitions. Even in a logical point of view, considerable interest attaches to the mental process involved in the development of the radiometer. The fact of repulsion being given, and its explanation postulated, a rapid method of exclusion was needed, by means of which the cruder and less consistent hypotheses could be filtered off. To this the inventor immediately and almost instinctively applied himself; nor would it be difficult to trace in successive modifications which the instrument has undergone the *tabula præsentiæ*, the *tabula absentiæ in proximo*, the *tabula graduum*, and the other tests which in Bacon's "Novum Organon" conduce "to a true and legitimate induction, the very key of interpretation." An attempt will be made in the following pages to show that "after an exclusion correctly effected, an affirmative form will remain as the residuum, solid, true, and well defined, whilst all volatile opinions go off in smoke."*

For this purpose it will be desirable to take a brief survey, in chronological order, of the various steps in the evolution of the last and most complete form of the instrument, the otheometer, as they occur in the proceedings of the Royal Society, the "Philosophical Magazine," and in one or two foreign periodicals.

On December 11, 1873, a paper was read by Mr. Crookes, which had been received in the preceding August, of which the title was, "On the Action of Heat on Gravitating Masses." The author therein stated that the experiments to be recorded arose from observations made when using the vacuum balance, in determining the atomic weight of thallium, for weighing substances of a higher temperature than the surrounding air and weights. There appeared to be a diminution of the force of gravitation, the experiments being instituted in order to render the action more sensible, and to eliminate sources of error.

The preamble furnishes a historical *résumé* of vague hints on the subject given by previous observers. The Rev. A. Bennet, in 1792, recorded the fact that a light substance delicately suspended in air was attracted by warm bodies; this he ascribed to air currents. Laplace spoke of the repulsive force of heat; Libri had made experiments, unsuccessfully repeated by Baden Powell; Fresnel obtained contradictory

* *Novum Organon*, Book II. par. xvi.

results with concentrated solar light acting on a fixed and a suspended disc; Saigey described experiments which appeared to prove that marked attraction existed between bodies of different temperatures. Forbes and Faye had also contributed to the subject.

The author then describes various forms of apparatus of increasing delicacy which enabled him to detect and render very sensible an action exerted by heat on gravitating bodies, which is not due to air currents or to any other known form of force. A balance was made of a straw beam with pith ball masses at the ends, enclosed in a glass tube, and connected with a Sprengel pump. The tube being full of air, a spirit lamp was passed along the lower part of the tube: the pith ball descended slightly, and then rose to considerably above its original position. It seemed as if the true action of the heat was one of attraction, instantly overcome by ascending currents of air. A glass ball full of heated water was afterwards substituted for the lamp. The pump was then set to work, and the effect of the hot body regularly diminished until the gauge was about 12 millims. below the barometer, when it was scarcely noticeable; at 7 mill. it ceased entirely. The exhaustion was, however, continued; and it appeared that at 3 mill. the ascent of the pith, when a hot body was placed beneath it, was equal to what it had been in air of ordinary density. With the gauge and barometer level, the upward movement was not only sharper than in air, but took place under the influence of far less heat, the finger sending the ball up to its fullest extent. A piece of ice produced an exactly opposite effect to that of a hot body.

An incandescent spiral of platinum wire was then placed within the tube, and produced exactly the same effects. The rays of the sun and different parts of the solar spectrum acted so energetically as to endanger the apparatus. Various substances were used as gravitating masses—ivory, brass, platinum, gilt pith, silver, bismuth, selenium, copper, mica, charcoal, and glass, among others. The apparatus was somewhat modified by suspending the index from a cocoon fibre in a long tube furnished with a bulb at the lower end, and the results were still identical. After comparing these with Cavendish's celebrated experiments, the paper ends with a purely tentative discussion of their cause, in which no particular form of radiation appears to be suggested. The next contribution to the subject is a paper by Professor Osborne Reynolds, received by the Royal Society on May 16, 1874, and read the following month, headed, "On the Forces caused by Evaporation from and Condensation at a Surface." He proceeds to show that the movements described by Mr. Crookes are due to the cause named in the title, and that they are valuable evidence of the truth of the Kinetic

theory of gases, namely, that gases consist of separate molecules moving at great velocities. His apparatus was a light stem of glass, with pith balls on its ends, suspended by a silk thread in a glass flask, so that the balls were nearly at the same level. Some water was then put into the flask, and boiled until all the air was driven out of the flask, which was then corked and allowed to cool. When cold there was a partial vacuum in it, the gauge showing $\frac{1}{2}$ to $\frac{3}{4}$ inch pressure. It was now found that when the flame of a lamp was brought near to the flask, the pith ball which was nearest to the flame was driven away, and that with a piece of ice it was attracted. The pith balls were more sensitive to heat and cold when the flask was cold and the tension low, but the effect was perceptible until the gauge showed an inch, and even after that the ice would attract the ball.

The reason why the repulsion from heat was not apparent at greater tensions was clearly due to convection currents which the heat generated within the flask.

The condition of the pith also perceptibly affected the sensitiveness of the balls. When a piece of ice was placed against the side of the glass, the nearest of the pith balls would be drawn towards it, and eventually stop opposite it. If it remained there for some time, the vapour would condense on the ball near the ice, while the other ball would become dry, as was shown by the former becoming heavier. When the ice was removed, the dry ball was found insensible to the heat, or nearly so, while that which had been opposite the ice was more than ordinarily sensitive.

If the flask were dry, and the tension of the vapour reduced with the pump until the gauge showed $\frac{3}{8}$ inch, then the vapour, though purely steam, was not in a saturated condition, and the pith balls, which were dry, were no longer sensitive to the lamp, though they would still approach the ice. The last two facts seemed to show that a certain amount of moisture on the balls was necessary to render them sensitive to heat. With a dry flask and an air vacuum neither the lamp nor the ice produced their effects, even when the gauge was as low as $\frac{1}{4}$ inch.

It was argued from these data that the real force in action was due to evaporation and condensation, a view which was reduced to greater accuracy by means of mathematical formulæ. The condensible vapour in Mr. Crookes's experiments was held to be that of mercury; and the necessity for a higher degree of exhaustion to be due to the fact that a larger proportion of air, a non-condensible gas, was mixed with the vapour, which also was not in a state of saturation.

Professor Reynolds's paper presents, in addition, a very remarkable appendix. "Since writing the above," he says, "it

has occurred to me that, *according to the Kinetic theory, a somewhat similar effect to that of evaporation must result whenever heat is communicated from a hot surface to gas.*"

The particles which impinge on the surface will rebound with a greater velocity than that with which they approached, and consequently the effect of the blow must be greater than it would have been had the surface been of the same temperature as the gas. And in the same way, whenever heat is communicated from a gas to a surface, the force on the surface will be less than it otherwise would be, for the particles will rebound at a less velocity than that at which they approach.

Of this important generalization of the view with which the paper started, mathematical demonstration is given. Convection currents are said not to have much to do with Mr. Crookes's experiments, as one can hardly conceive that much heat could be communicated to the gas or vapour in such a perfect vacuum as that he obtained, unless indeed the rate of diffusion varies inversely as the density of a gas. To this a note is added, which appears to go even deeper to the root of the matter than the text. "Professor Maxwell," it says, "has shown that the diffusion both of heat and of the gas varies inversely as the density; therefore, excepting for convection currents, the amount of heat communicated from a surface to a gas would be independent of the density, and hence the force (F) (previously given as the force arising from evaporation) would be independent of the density; that is to say, this force would remain constant as the vacuum improved, while the convection currents and counteracting forces would gradually diminish."

It will be seen that this valuable paper, which has been abstracted in considerable detail, ends by suggesting a far more general solution of the problem than that which is implied by its title.

In November of this year occur the remarks of the President of the Royal Society already cited.

What may be termed the second stage in the history of radiometry commences with a paper of Mr. Crookes's, received by the Royal Society on March 20, 1875, and read on April 22. It is marked by the same high level of experimental power, the same unwearied patience in varying experimental conditions, and by the same combination of scientific imagination with accuracy of statement and mechanical aptitude as was the first.

It describes necessary improvements in the Sprengel pump, and different forms of radiometric apparatus, by means of which the sensibility of the instrument is materially increased. The bulb is surrounded with adiathermanous media, and with a second vacuum. Measurement is substituted for mere demon-

stration of the occult force. The radiometric balance, shaped like an inverted T, is developed, and the similar behaviour of various gases at the minimum tension is established. The effect of interposing various screens, such as rock salt, rock crystal, smoky talc, plate glass, water, alum, calc spar, and ammonio-sulphate of copper of varying opacity, is tried. Experiments are made with the electric and solar spectrum passed through a quartz train, showing the activity of the ultra-violet rays.

After some discussion of the neutral point between attraction and repulsion, various explanatory theories are adverted to. The air-current and electrical theories are considered to be abundantly disproved. Professor Reynolds's evaporation is included in this catalogue, from the impossibility of conceiving that sufficient gas or vapour was present, after repeated heating of the instrument to redness at the highest attainable exhaustion, to drive backwards a heavy piece of metal, or generally to produce the effects ascribed to it. The writer most explicitly guards himself against substituting for these any theory of his own.

A supplement, received on April 20, examines more closely radiation from black and white surfaces, the former being the most energetically repelled. Here, for the first time, occurs the familiar name radiometer, and the substitution of rotation for oscillation. Four radial arms carry discs of pith lamp-blacked on corresponding sides, mounted on a central pivot, and enclosed in a globular vacuum. They revolve under the influence of radiation with a rapidity proportional to the intensity of the incident rays. Several of these instruments were exhibited at the *soirée* of the Royal Society, and from this period may probably be dated the great public interest manifested in the phenomena. It is deserving of notice that in this paper occurs an allusion to the "limiting walls of the space" in which the rotation takes place, as though the possibility of the action being one of mutual reaction had already presented itself to the writer.

At the anniversary meeting of the Royal Society on November 30, 1875, the Royal medal was awarded to Mr. Crookes as already stated.

Some experiments on the methods of obtaining perfect vacua formed the subject of a paper read before the Royal Society of Edinburgh on July 12, 1875. A brief *résumé* is given in "Nature" of July 15, under the heading "Charcoal Vacua." It is there stated that the writers, Professors Tait and Dewar, had taken advantage of the power charcoal has of condensing gases. While the exhaustion by means of a mercury pump is going on, the charcoal is kept heated; when the exhaustion has been carried as far as possible, the vessel is sealed, and, as the

charcoal cools, it condenses the very small residue of gas there may be present. They test the vacuum by the passage of an electric spark.

Professor Dewar then noticed that the effects of light and heat had been tried by many experimenters, and that in the "Edinburgh New Philosophical Journal" for 1828 there is an account of experiments by Mark Watt on the subject, made with apparatus differing little in appearance from that used by Mr. Crookes. A general account of Mr. Crookes's results was given, and the statement was made that this observer considered the results "inexplicable."

A substance opaque to heat-rays was then interposed between the candle and the balance, a layer of water $\frac{1}{4}$ inch thick diminishing the deflection to $\frac{1}{8}$ of the original amount. A smoked piece of rock salt or a solution of iodine in bisulphide of carbon were then interposed, and the deflection was found to be only diminished by the obstruction due to the glass walls of the tank.

Two equal discs, one of rock salt the other of glass, were attached to the glass fibre. The rock salt was inactive to the beam, the glass was active. The reason was given that the former, being transparent to heat, was not heated, whereas the glass was. The back of the rock-salt disc was then coated with lamp-black. Still there would be attraction. The heat and light, passing through the rock salt, were absorbed by the lamp-black at the surface of contact. The lamp-black is heated, but is so bad a conductor that before the heat can be conducted through it, it is conducted through the rock salt, heating it, and causing repulsion. The next modification was to substitute clear and ordinary sulphur for the salt. Clear sulphur, when acted on by light, resumes the appearance of ordinary sulphur, with disengagement of heat. A beam being thrown on this, the effect was attraction, the back being heated, and repulsion, there being attraction on the other side.

When the action takes place at ordinary pressure, it is probably due to convection currents. The air in front of the disc is heated and ascends, leaving a vacuum, and hence the disc advances. To understand the action when the exhaustion is more perfect, the quantity of gas actually present must be considered. A vessel of a like capacity would hold a bubble $\frac{1}{100}$ inch in diameter at ordinary pressure. It has been shown that the average path of molecules between two collisions is about $\frac{1}{10000}$ millimetre. If the pressure be reduced to $\frac{1}{4000000}$ the mean path will be 400 millimetres, or about a foot and a half. When, therefore, the gas is rare, the particles may get a long way off before they meet others, and so the action becomes perceptible. It was shown that the total mechanical action on a

square centimetre of black surface, from the radiation of a magnesian lamp at a distance of 150 millimetres, did not exceed a continuous pressure of $\frac{1}{50}$ milligramme.

On January 5, 1876, a third communication was received by the Royal Society, and read on February 10. The influence of various coatings on radiating and absorbing power is herein discussed, and a quantitative instrument on the principle of Bohnenberger's electrometer is described, in which repulsion is balanced against the magnetic couple, a small magnet being attached to the pith, and a controlling magnet mounted adjustably on the outside.

This immediately gives the apparatus practical value as a photometer, by balancing a standard candle against the source of light to be tested. The same balance can be made between different colours.

Here, for the first time, we meet with the vernacular name of "light mill" applied to the machine, which, though probably imitated from the "mouse mill" of another distinguished physicist, undoubtedly had the fault of implying a theory, and certainly affords a good instance of Bacon's "Eidola Fori."

A fourth communication, read on the same day, details experiments on the spectrum admitted to a radiometric balance through a quartz window. The maximum effect is found to be in the ultra-red, the minimum in the ultra-violet.

Then comes the momentous question, "Is the effect due to heat or light?" It is noted that "there is no real difference between heat and light; all we can take account of is difference of wave length; and a ray of different refrangibility cannot be split up into two rays, one being heat and one light."

Sunlight filtered through alum, glass, and water, so as to cut off the whole of the dark-heat rays, produced a deflection of 105° in the torsion apparatus; whereas on interposing a solution of iodine in disulphide of carbon, the deflection sank to 2°, showing that the deflection previously obtained was almost entirely due to light. A number of other substances were also experimented on, so as to get comparisons of action.

Professors Tait and Dewar's experiments, published in "Nature" for July 15, 1875, are examined by a special apparatus, and with different results from those of the original observers, for whereas they state that rock salt is inactive to the light of a candle, and glass is active, the difference between them is found by several concordant observations to be only in the ratio 39 : 40.

An extremely delicate torsion balance is lastly described, by means of which the radiation from a candle is measured in decimals of a grain; at twelve inches off it is found to be 0·000444 of a grain, at six inches 0·001772, or close to the

theoretical amount for half the distance, *i.e.*, four times, which would be 0·001776.

An observation on the "weight of sunlight" is thus obtained. On a dull day in December it is found equal to 10·2 candles, six inches off. This is by calculation equivalent to 2·3 tons per square mile.

Leaving at this point, according to the chronological order adopted, communications to the Royal Society, an important paper is contributed to the "Philosophical Magazine" by Mr. G. Johnstone Stoney. It commences by reciting the measurements just given, with others contained in an article on "weighing" a beam of light, contributed by Mr. Crookes to the periodical "Engineering" of February 18, 1876. The pressure is computed as equal to the hundredth of a milligramme on the square centimetre. The object of Mr. Stoney's communication is "to show that an excess of pressure of about this amount will arise under the operation of known laws."

He begins by estimating the outstanding pressure in the chamber of the instrument as about $\frac{1}{10}$ millimetre of mercury, caused in part by atmospheric air, in part by vapours of mercury and hydrocarbons, with, perhaps, other substances. Upon the vane fall such radiations from the candle as can pass through glass, which are competent to heat the blackened disc but not the transparent glass. It is assumed that the disc is thus heated $\frac{1}{10}°$ Centig. more than the glass, and that it in turn warms a layer of air in contact with it. Such a layer, in ordinary air, would be thin, about one "fourth metre," or the thickness of a sheet of paper, for 20° Centig.; and for 0·1 half a "sixth metre," explained as being a quantity equal to the wave length of light of mean refrangibility, and $\frac{1}{16}$th the size of human blood globules. Now, in the vacuum chamber the density is assumed at $\frac{1}{100000}$ of an atmosphere, and the thickness of the heated layer in this attenuated medium is $10{,}000\frac{4}{3}$ times greater, or more than a decimetre, thus able to reach to the walls of the globe. "Some of the additional momentum communicated to molecules of air by the heated disc, instead of expending itself in intra-aerial collisions, and thus increasing the general temperature and pressure of the air, makes its way across the intervening stratum to the opposite walls of glass, where it occasions an increased pressure against them, of which the result is directed perpendicularly from the disc. An excess of force, equal and opposite to that on the glass, acts against the front of the disc, and is sufficient to account for the phenomena Mr. Crookes has investigated. The molecules reach the disc with velocities corresponding to 15°, and are thrown off from it with velocities corresponding to 15°·1. The augmentation of pressure will be half what would arise if they had

reached, and left it at the higher temperature." The uncompensated excess of pressure is, therefore, 0·000,011,5 of a gramme per square centimetre; Mr. Crookes making it = 0·000,01. It is obvious that all needed to substantiate the truth of this explanation was experimental evidence of a reactive force on the case of the radiometer, corresponding to the action on the vanes. This was immediately supplied in a paper read before the Royal Society on March 23, 1876, by Mr. Arthur Schuster, of Owens College. "Whenever," he says, "we observe a force tending to drive a body in a certain direction, we are sure to find a force equal in amount acting in the opposite direction on the body from which the force emanates. If the force is directly due to radiation, the reaction will be on the radiating body; if, on the other hand, it is due to any interior action, such as the one suggested by Professor Reynolds, the reaction will be on the enclosure of the moving bodies."

This proposition was easy to test by experiment. A radiometer was suspended on the bifilar principle, by two cocoon fibres, from the top of a vessel which could be exhausted, and its slightest movement detected by an attached mirror. The light of an oxyhydrogen lamp was concentrated on the vanes, which then revolved about 200 times a minute. The light being cut off by a screen, the position of the case was read by means of the dot of light on a scale. The screen was then suddenly removed, and in every case a large deflection was observed; the vessel being deflected in the opposite direction to that in which the vanes turned. When the velocity of these had become constant, the vessel returned to its original position. On suddenly cutting off the light, the vessel was again deflected, but in the opposite direction to that on starting the experiment. These experiments are easily explained, on the assumption that the force acting on the vessel enclosing the vanes is exactly equal and opposite to that acting on them. While the velocity of the latter is increasing, a force acts in the opposite direction on the vessel. When the light is cut off, the reaction of resistance will act on the enclosure, and the enclosure will turn in the same direction as the vanes.

"By means of the reaction of the enclosure," concludes Mr. Schuster, "I have been able to calculate the strength of the force; and I have found that the pressure on a surface on which light of equal intensity to that used in my experiments falls, is equal to that produced by the weight of a film of water on a horizontal surface equal in thickness to the length of a wave of violet light."

A paper by Professor O. Reynolds was read on the same evening, commenting on Mr. Schuster's experiment, and somewhat intensifying Mr. Crookes's differences of view; describing

him as "entirely repudiating" Professor Reynolds's explanation of the phenomena. It will be seen from the preceding page that this is hardly a fair representation of the remarkably impersonal and unbiassed attitude which Mr. Crookes maintained throughout the discussion.

On the 30th of the same month Mr. Crookes again takes up the subject in a paper "On the Movement of the Glass Case of a Radiometer." He describes a large radiometer with ten arms, eight of brass and two formed of a long watchspring magnet. The directive power of the earth prevents rotation unless a candle be brought near; but if once started it continues to revolve with the light some distance off. It was floated in a vessel of water, and four candles were placed round it so as to set the arms in rotation. A mark was placed on the glass envelope to show the amount of this. It turned about once an hour with the vanes. On bringing a powerful magnet near the moving arms they stopped, and the envelope began to revolve in the opposite direction to the arms, about once in two minutes. When the candles were removed and a magnet used to rotate the vanes, the case rotated in the same direction about once in three minutes. These experiments showed that internal friction, whether of point and socket or of vanes against residual air, is considerable.

He concludes by specifically denying his antagonism to "some strongly urged explanations," saying that he has already stated that he wishes to keep free from theories.

The April number of the "Philosophical Magazine" contains a further explanation of Mr. Johnstone Stoney's views as to the radiometer, wherein he distinguishes two stages: (1) the brief period of adjustment which arises when the light first falls on the blackened face of the disc; and (2) the permanent state which supervenes when the period of adjustment is over. During the former stage, in a partially exhausted globe, a thin layer of air in contact with the disc has been warmed and rarefied; another of varying temperature and density is in contact with the glass. If the exhaustion be carried farther, these two layers will become thicker until there is not room between the disc and the glass for their full development. Then arises what he terms "Crookes's pressure." "A procession of swift molecules at once commences, which is ever starting from the front or warmed side of the disc (the heater of the little engine) and jostling its way to the opposite hemisphere of cool glass (the cooler of the heat-engine). Another procession is as constantly starting from the cool hemisphere of glass, and working its way both up to the disc and to the regions behind the disc. Any member of the slow procession that comes into contact with the front of the disc is, in rebounding, converted into a member of the swift

procession; and any member of the swift procession that comes into contact with the glass is converted into a member of the slow procession. The characteristic of each procession is retained over a considerable distance, although it is gradually effaced as the procession advances. If there is room between the disc and the glass for the entire gradient, that is, for the whole thickness of those layers which I have described, then that part of the slow procession which reaches the disc will not only have lost its sluggishness, but will have attained the full molecular speed of the beginning of the swift procession; and the swift procession, where it comes into contact with the envelope of glass, will have become as slow as the beginning of the slow procession. In such a case there will be no Crookes's pressure. If there is not room for the full gradient, each procession will retain a portion of what characterises it when it reaches its destination. It would require the whole gradient to produce such a defect of density as would entirely compensate for the greater average momentum imparted by each molecule that strikes the front, as compared with the momentum imparted by each molecule striking the back of the disc."

In a vertical disc Crookes's pressure will be accompanied by the forces occasioned by a convection current. This will influence the motion of the vanes in three ways—(1) It will bring a continuous supply of cold air to the front of the disc, which, being thrown off with augmented molecular motion, will cause a recoil of the disc in the same direction as Crookes's pressure. (2) The convection current will also occasion a defect of tension in front of the disc, by that law of fluids in motion according to which the tension decreases along a stream wherever the velocity increases. This will occasion a minimum of tension where the velocity of the convection current is greatest, *i.e.*, in front of the disc, and will thus give rise to a force opposed to Crookes's pressure. (3) Lastly, the convection current, after being turned downwards by the roof of the little chamber, is likely to become a draught blowing upon the back of the disc with a force also opposed to Crookes's pressure. The resultant of these three forces seems in all the experiments to have been opposed to Crookes's pressure. At any particular degree of exhaustion it is only the difference between this resultant and Crookes's pressure which becomes apparent. It is evident that there is a certain tension, depending in some degree upon the form of the instrument, in which the above excess will be at a maximum.

In the "Philosophical Magazine" for May is a "Theory of the Radiometer," by Professor Challis. He commences by stating that rays of light incident on opaque substances are partly reflected without undergoing transmutation, and are partly

intromitted. The latter part is transmuted into rays of the kind which, by their dynamical action, produce *heat of temperature* as distinct from *radiant heat.* This is what takes place on the bright side of each vane. On the blackened side none of the light is regularly reflected, and the whole is transmuted into heat of temperature. The increase of temperature is therefore greater on the black than on the bright surface. The incident light thus produces an abnormal state of the atoms at and near the surface of the vane, analogous to the state of the superficial atoms of a body electrified by friction. He considers that the forces may result from the dynamical action of ætherial undulations. There will be a decrement of ætherial density from the dark towards the bright surface, and the atoms, being immersed in this variation of density, will be urged as if the vane were pushed on the black surface.

Thinking, according to this theory, that the rotation of the vanes might be affected by the streams of a magnet in the neighbourhood, Professor Challis found on trial that such was the case, the rate of revolution being much reduced by the proximity of a magnet of considerable power.

On June 15, 1877, Mr. Crookes again appeared before the Royal Society with a communication upon the "Influence of the Residual Gas." He states that he has been assisted by Professor Stokes. He admits that the first and most obvious explanation was that the repulsive force was directly due to radiation. Further consideration, however, showed that the very best vacuum which could be produced might contain enough matter to offer considerable resistance to motion; indeed, an instrument had been exhibited in 1876 to demonstrate this fact, which had also been proved by Dr. Schuster's experiments.

An apparatus had recently been constructed to discriminate experimentally between the viscosity of residual gas, friction of the needle point, and the torsion of the suspending glass fibre. It had been shown by this means that Professor Clerk Maxwell's law of the independence of a gas's viscosity and its density was practically correct. By using this apparatus the following measurements had been made:—

1. The logarithmic decrement of arc of oscillation when under no influence of radiation.

2. The successive swings and final deflection when a candle shines on one end of the blackened bar.

3. The appearance of an induction-spark between platinum wires.

The first measures the viscosity, the second gives the force of the candle's radiation, the third enables an estimate of the progress of the vacuum to be made.

It appears that up to a level position of gauge and barometer the viscosity of dry air does not vary much. On farther exhaustion radiation becomes apparent, viscosity being unaltered. The latter then begins to diminish and the former to increase. At length, radiation approaches a maximum, but viscosity begins to diminish rather suddenly. When this last has sunk to one-fourth, radiation diminishes, reaching less than one-half of its maximum. The number of gaseous molecules present is then not practically infinite, and the path of each of them is no longer small as compared with the globe. This point of exhaustion is far beyond that which is impervious to an induction current.

The conclusions come to are—That the force is due only indirectly to radiation; that the viscosity of the residual air is almost as great as at the atmospheric pressure; that with other gases the results are similar in kind but different in degree; and, lastly, that the repulsion is due to thermometric heat acting between the surface of the moving body and the case of the instrument.

It may be best to notice at this stage some foreign contributions to the history of the radiometer. As early as September, 1875, a paper appeared in Poggendorf's "Annalen," by Dr. F. Neesen, which advocated the influence of currents rising from inequalities of temperature. He used a modified form of apparatus, by which he established the fact that deflection diminishes in proportion as vacuum is produced, and is at last supplanted by the opposite deflection. This he attributed to heat currents, and herein he was followed by M. Poggendorf himself in the subsequent November, who was of opinion that the motions would not take place in a perfect vacuum. The whole subject was, however, still in its infancy.

In 1877 an excellent memoir was contributed to the "Annales de Chimie et de Physique" by MM. Bertin and Garbe. The writers commence with a historical summary of experiments, adding to them an extremely ingenious modification of the instrument brought before the Académie des Sciences by Mons. Salet. The globe in this case contains two sets of vanes, one above the other, both of them fixed. Between them is a horizontal plate of mica turning on a point. Directly light strikes the apparatus, the mica disc begins to turn in the opposite direction from that which the vanes would assume if they were free to move. The plate of mica may be considered to represent a portion of the case which has become movable, and therefore rotates just as the whole envelope does in Mr. Schuster's experiments.

A still more complete experiment, due to Signor Righi, is quoted from the "Scienza Applicata," Vol. I., part 2, page 8, in

which, after repeating the flotation and suspensory contrivances, the radiometer is floated on water upside down, so that its vanes rest on the projecting piece intended to prevent their falling off the needle point. In this case they form one piece with the case itself. The strongest beam from the oxyhydrogen lamp then directed upon them fails to produce the slightest deviation.

Upon these data a mathematical investigation of the forces involved in the rotation is entered into, in which the comparative weights of the case and the vanes, previously ascertained, are considered with reference to the combined motion of the two. It was found, that with a radiometer suspended in air, the currents due to its heating by the ray of light interfered with the strict ratio of mobility. The instrument was therefore suspended under the receiver of an air-pump, and the pressure reduced to 3 millimetres of mercury. Experiments made under these conditions agreed well with one another. Tables of these are annexed. The ratio of the vanes' speed to that of the case was always a little too great, as if the latter had been slightly retarded by the torsion of the suspension and the residual air of the receiver.

A memoir by Professor Challis, contributed to the April number of the "Philosophical Magazine," upon the cup-shaped radiometer of Mr. Crookes, with both sides bright, can only be briefly named for lack of space. The author attributes the rotation to thermo-electric ætherial currents, and appears to deny the presence of residual gas as the cause of motion.

On November 16, 1876, Mr. Crookes brought another series of experiments before the Royal Society, stating that he had succeeded in experimenting at still higher exhaustions, and with different gases. By means of a McLeod gauge he had been able to measure the pressure at any desired stage. He had thus estimated repulsion and viscosity, plotting the observations in curves, showing the relation of the two to one another. These are given with the paper.

Some technical improvements, such as the use of phosphoric anhydride instead of monohydrated sulphuric acid for drying the gases enable the rarefaction to be pushed to a higher degree than before. In this way, and sometimes with the assistance of chemical absorption, it is not difficult to exhaust a radiometer to such a point that it will not move to a candle placed a few inches off; but it has not been possible to stop the movement of the beam in the torsion apparatus.

The improvements added by Mr. Gimingham to the mercury pump render it so easy to obtain high exhaustions, that in preparing radiometers he now exhausts to one or two millionths of an atmosphere, then uses a hot-air bath of 300° C. to drive off occluded gases, and then attenuated air is let in until the

greatest sensitiveness is obtained. Rotating instruments will not move to moonlight, but a sensitive torsion balance does so.

The writer adopts Mr. Johnstone Stoney's explanation as given above, which has been tested by rotating the same fly in two bulbs of different size. An ingenious instrument has been made with a large and small bulb containing a single fly which can be balanced in either of them, its vanes being distant $\frac{1}{4}$ inch from the walls of one and $\frac{1}{2}$ inch from those of the other. In the smaller bulb the fly rotates about 50 per cent. faster than in the large.

The chief novelty, however, in this paper is the influence of the shape of the surfaces on the rotation. If the aluminium plates latterly used as vanes were turned up at the corners so as to make the blackened surface concave, it was attracted instead of being repelled by a candle, though still repelled by dark heat. Sloping the plates of a lamp-blacked mica radiometer, so as to have the black outside, and more facing the side of the bulb, greatly increases the sensitiveness.

Cup-shaped and conical discs materially modify the action and require more experimental investigation. A convex surface seems to cause greater pressure between itself and the bounding surface than one which is concave. Many illustrations of these facts are given in the paper, which want of space alone forbids our reproducing.

We thus arrive at the last in the long series of Mr. Crookes's papers, a series which his immense energy and unparalleled industry render it laborious even to chronicle. This was read on April 26, 1877, before the Royal Society. He therein describes a new form of instrument for which he suggests the title of Otheoscope (from ὠθέω, I propel).

In the radiometer, the surface which produces molecular disturbance is mounted on a fly, and is driven backwards by the excess of pressure between it and the sides of the containing vessel. As a heat-engine this arrangement is imperfect. The *heater* should be stationary, and the *cooler* movable. The driving surface should be of large size, and a good conductor of heat. The blackened surface acts as if a "molecular wind" were blowing from it, principally in a direction normal to the surface. This wind blows away whatever movable body happens to be in front of it, irrespective of colour, shape, or material; in its capability of deflection from one surface to another, its arrest by solid bodies, and its tangential action, it behaves in most respects like an actual wind.

The otheoscope, founded on these data, may be made similar to the radiometer, or in different forms. In the former case, at one side of the bulb is fastened a plate of mica blackened on one side, in a vertical plane. The vanes are of clear mica, and

in rotating pass the plate, leaving a space of about a millimetre. Light falling on the clear vane produces no motion, but if shining on the black surface the fly rotates as though a wind were issuing from this surface. In the latter case a large horizontal disc is made to revolve by the molecular disturbance on the surface of inclined metallic vanes, which are blackened on both sides so as to absorb the maximum amount of radiation; or inclined aluminium vanes are driven by molecular disturbance from a thick black mica disc below blowing through them. Both these last work on the smoke-jack principle. Six forms of otheoscope and thirteen new forms of radiometer are described in this paper; all, however, vary chiefly in mechanical arrangement, but not in the fundamental principle upon which they are based.

Here what may be termed the official history of the radiometer may be said to end for the present. But of course it has formed the subject of many popular lectures, and of articles in semi-scientific and literary periodicals. Of the former the most remarkable was a lecture given by Mr. Crookes himself at the Royal Institstitution; and in the latter class may be named memoirs in the journal "Engineering" and in the "Nineteenth Century." To the latter paper a contribution was also sent by Dr. Carpenter, in which, while commenting on Mr. Crookes's views with respect to spiritualism, he appeared to depreciate that gentleman's philosophical capacity on the ground that he had at first attributed the motion of the radiometer to the direct action of light. Professor Carey Foster commented on this article in his address as chairman of the Physical branch of the British Association. Dr. Carpenter replied by a letter in the columns of "Nature;" and hence arose a long and rather acrimonious controversy, in which all the gentlemen hitherto named, and some others, were for some months engaged. It will be seen from the narrative given above that the inventor certainly leaned at first to the Light hypothesis, which many experiments seemed to favour. But he certainly did not commit himself to it. Nor indeed, if he had done so, would it have been, as Dr. Carpenter seems to think, any evidence of logical imbecility and almost of mental obliquity. Oscillations of opinion around a new, startling, and unexplained fact are not strictly errors; but only provisional and perhaps feeble guesses, easily cleared away by a more forcible generalization. There is no doubt, for instance, that Faraday attributed the rotation of the plane of polarized light under the influence of an electro-magnet to some action of magnetism on light itself, and not, as has since been shown to be the case, on the molecular arrangement of the particles of heavy glass through which the beam was made to pass. But it never occurred to anyone to suggest that he in any way sank from his

high intellectual standard by the supposition; still less to connect the undoubtedly false hypothesis with his peculiar theological tenets.

Very little that was new came out of the long correspondence named above. The topic, already well threshed out, was threshed over again; the only grain of novelty being a difference between Professor Reynolds and Mr. Storey as to the exact proportion in which molecular motion and convection currents conduce to the ultimate result.

Perhaps one remark may be justifiable on the subject of spiritualism, so quaintly superinduced on matter apparently irrelevant; namely, that the candid and impartial tone throughout maintained by the discoverer of the radiometer leads to the belief that his apparent support of spiritualism is not so much credence, or an 'act of faith,' as a characteristic determination to examine any *supposed* fact, or series of asserted phenomena, with the widest liberality and the utmost willingness to be taught. To some minds it seems an anterior axiom that discrepant or unexplained observations should be tested by the method of strict investigation. Dr. Carpenter, on the other hand, refers to the general common sense of mankind, and of scientific men in particular, as having put spiritualism out of the pale of belief. It has, like an Athenian of old, been ostracized by popular disapproval. It is not to be denied, however, that the determination to explore, even in the face of *à priori* improbability, is more characteristic of the scientific temper; and to attempt to coerce such exploration by appeals to the *consensus omnium bonorum* may perhaps be learnedly named an act of scientific hyper-Grundyism.

W. H. Stone.

REVIEWS.

THE SWISS LAKE-DWELLINGS.*

THE history of the past teaches us whence our progenitors came, how their arts and customs originated, and how our lines of thought and action were at first marked out feebly by an incipient civilization, and have been more deeply channelled, for the diffusion of moral integrity, good policy, and personal comfort, in later ages. Without the experiences of history no nation can be well governed; without some knowledge of the past no man can be an eminent citizen of the state; without a respect for the material evidence of the lives and doings of foregone generations no man, no community, is at one with all the proper feelings and duties of humanity.

Where research among ancient parchments, papyri, coins, and other definitely inscribed monuments ceases to aid us in deciphering the past, we well know that the tombs and buried homes of still earlier, but unlettered races, yield in many places abundant material for the historian. The antiquary searches and sifts such relics for evidences of the pre-historic peoples, their race-characters, their utensils and weapons, their associated animals, wild or tame, their usual habits of thought and occupation, and sometimes he can even form a notion of their objects and modes of worship.

We lately noticed a most valuable repertory of facts† illustrating the customs and surroundings of some ancient tribes on British ground. We have now to draw attention to an enlarged edition of Dr. Keller's descriptions of the ancient Lake-dwellings of Switzerland and elsewhere. Of various ages, probably during a very long period of time, these timber structures in shallow water, near to, but separated from the shore, were habitually made in many parts of Europe, including the British Isles; and such are still constructed in South America, Central Africa, Japan, and elsewhere. Defence from enemies and wild beasts was probably the chief motive for this kind of dwelling. When burnt by invaders, or deserted under other circumstances, the relics of the piles and floors, of pottery, of tools and ornaments, of stone and metal, and of charred wood, cordage, cereals, &c., are found on the sites, and made to tell the tale of the past, so far as antiquary and naturalist can interpret their meaning, uses, and associations.

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* "The Lake-dwellings of Switzerland and other parts of Europe." By Dr. Ferdinand Keller, &c. Translated by J. E. Lee, F.S.A., &c. Second Edition, greatly enlarged. 2 vols. 8vo. pp. 725, Plates 206. London: Longmans & Co. 1878.

† Canon Greenwell's "Ancient British Barrows." See above, page 73.

Dr. Keller, the original observer and recorder of these discoveries in the Swiss Lakes, has not ceased from his well-directed labours, and, with his fellow-workers at Zürich and elsewhere, has amassed further stores of knowledge about the old Lake-dwellers. Mr. J. E. Lee has continued to gather and incorporate in his very useful translation of his learned friend's book the most important results of these well-sustained explorations. The new matter, occupying more than 260 pages, and illustrated by 109 new plates, gives Dr. Keller's Seventh Report, with new or enlarged accounts of Moringen, Lüscherz, Schaffis, Vingelz, Auvernier, Cudrefin, Heimenlachen, Constance, and Schussenried, and of the lakes Bienne, Geneva, Baldegg, Mond, Atter, Hallstatt, Neusiedler, and Paladru; besides places in Northern Italy and elsewhere, together with accounts of several special researches on bones, stones, canoes, &c.

Further notes on the Irish Crannoges, by Mr. Kinahan, and the Rev. E. Dumbleton's notice of a Welsh Crannoge, are added. The Irish Bog Cabin, described by Mudge in "Archæologia," vol. xxvi., and noticed by Lyell in his "Antiquity of Man," appears to belong to the same category of structures, and might have been mentioned.

Besides the English pile-structures at London, described by General Lane Fox, Mr. Lee might have added the discovery of such piles in the Norfolk Meres, due to Sir C. Bunbury, and recognized by Mr. W. M. Wylie in "Archæologia," vol. xxxviii., 1859, p. 11 (of the Memoir); and we may add that indications of pile-dwellings in Berkshire were described by a F.S.A., since deceased, before the Wiltshire Archæological Society at Hungerford in 1869.

Almost at the time of the publication of this compendious new edition, further ground was exposed at Estavayer and elsewhere on the Lake of Neuchâtel by works of drainage made in 1877. Unfortunately, though the Cantonal Government reserves the monopoly of search for antiquities, these are continually poached and carried off, without systematic observation as to their position and character.

We must congratulate the veteran antiquary of Zürich on the continuation of his praiseworthy labours, and on the extension of their results among us in this rich, well edited, and excellent translation by Mr. J. E. Lee. The scientific researches have been carried on voluntarily and assiduously for the benefit of the community; and the translation and its enlarged edition have been evidently a labour of love, and a cordial friendly tribute to the master's worth.

DEVONIAN AND CARBONIFEROUS FOSSILS.*

NEARLY ten years ago Dr. Bigsby issued a "Thesaurus Siluricus,' or tabular list of described Silurian fossils from all parts of the world, furnishing in a very condensed form an immense amount of useful information upon their distribution in space and time. Since the publication of the above work its venerable author has been almost constantly engaged in the

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* "Thesaurus Devonico-Carb niferus. The Fauna and Flora of the Devonian and Carboniferous periods. The Genera and Species arranged in tabular form, showing their Horizons, Recurrences, Localities, and other facts." By John J. Bigsby, M.D., F.R.S., F.G.S. 4to. London: Van Voorst, 1878.

preparation of a similar book upon the fossils of the Devonian and Carboniferous periods, which has at length appeared under the title of "Thesaurus Devonico-Carboniferus.'

The general plan that he has followed is the same in this as in his former work, but there is a little difference in the treatment of its two sections. In treating of the Carboniferous series, its wide distribution and great importance have led the author to separate the registers of species from North America and the European area, and to indicate the countries and states in which they occur in a series of columns, whilst by placing the American and European lists on opposite pages he is enabled to present the whole information with respect to each genus and species at one view, and at the same time to furnish a means of contrasting the fauna and flora of the two richest and best worked regions. The Carboniferous fossils from localities outside the areas above indicated are catalogued separately in special lists. In the case of the Devonian the smaller extent of the subjects permits all the information to be brought together in one table, and the author has not considered it necessary to separate the North American fossils from the rest. Some notion of the labour the author must have undergone in the preparation of these elaborate tables may be formed from the fact that he enumerates in them, with the particulars above indicated, over 14,000 species of fossils.

The book, however, contains more than this, and vindicates its title to be called a "Thesaurus" by other claims. We find in it, besides discussions of nearly all points of interest that can arise from the consideration of such a series of palæontological tables, bibliographical lists of value, and notes on the recognised horisons and subdivisions of the Devonian and Carboniferous formations in various countries, often giving the views of different authors and always indicating the source of the information, so as to enable the student wishing for further information to go at once to head-quarters.

If, as Solomon tells us, "of making many books there is no end, and much study is a weariness of the flesh" (and there are few naturalists of the present day who will not subscribe at all events to the former proposition), students of the Palæozoic rocks can hardly fail to feel under great obligations to Dr. Bigsby, for having taken so much of the "weariness" upon his own shoulders. Although we have no doubt that imperfections might be indicated in his present work,* and its full utility can only be realized by careful study of its contents, the enormous amount of information brought together in it renders it a perfect mine of knowledge to the palæontologist and geologist.

ANTHROPOLOGY.†

OF all the departments into which the great science of Biology is divided, Anthropology, if we are to judge from many of the works published upon it, is the one which calls for the widest range of knowledge on the part of its votaries. From some indications, especially German ones, the

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* We may notice that at p. 26 the Merostomata are represented as equivalent to Articulata, instead of as a subclass of Crustacea; and that at p. 125 the Fichtelgebirge are inserted as if they belonged to Spain.

† "Anthropology." By Dr. Paul Topinard. With preface by Professor Paul Broca. Translated by R. T. H. Bartley, M.D. 8vo. London: Chapman and Hall. 1878.

proper motto for a treatise on Anthropology would be that prefixed by Southey to his well-known book, "The Doctor,"—*De omnibus rebus et quibusdam aliis*,—for it would appear that the complete anthropologist has not only to study all the morphological and physiological phenomena presented by man and other animals, the relations of man to the universe, his mental, moral, and social qualities as observed in the different varieties of mankind, in fact all the observable phenomena which may fairly claim the attention of a naturalist, but he must also possess a considerable acquaintance with metaphysics, which last is a hard condition to impose upon any one.

M. Topinard in his treatise on Anthropology, a translation of which is just published by Messrs. Chapman and Hall in the "Library of Contemporary Science," does not make quite such heavy demands on the intellectual powers of his readers. His book furnishes an excellent summary of the present state of Anthropology (of course according to the author's personal views in all disputed points); and the full description of the methods of research adopted and the kind of investigation on which anthropological results are founded, will render it an admirable guide for the student in consulting special works on the subject, and a most useful handbook for travellers in distant lands.

At the close of a short introductory chapter, in which the author defines his science and sketches out the general plan of his work, he treats of the classification of the Mammalia, and indicates the two points of view from which the position of man in the system have been regarded by different zoologists—namely, that according to which he is to take rank as a distinct order of Mammalia, and that which shows him as merely the highest type of an order (Primates), including also the apes, monkeys, and lemurs. "The question," as the author says, "resolves itself into the following terms:—What is the value of the characteristic points of difference between man and monkeys, and especially the anthropoid apes? Are these differences as great as those which separate two families or two orders?"

The succeeding section of the work (Part I.) is devoted to the consideration of this question, for the elucidation of which the author describes the structure of the human body, and especially of its more characteristic parts, at considerable length, and compares its characters and some functional and other peculiarities with those presented by the animals universally admitted to approach man most nearly in the zoological scale. The conclusion at which he arrives is that man is anatomically more nearly related to the anthropoid apes than these are to the old world monkeys, which stand immediately below them, and which again are, he thinks, more nearly allied to the American monkeys (Cebidæ) than to the anthropoid apes. Hence "the separation to be made at the extreme of the series, between the inferior monkeys and man, can only* be logically placed between the anthropoid and the so-called common monkeys. This leads us to Mr. Huxley's classification: (1) Man and the anthropoid apes; (2) the monkeys of the old and new continents; (3) lemurs." But M. Topinard is not satisfied with Professor Huxley's arrangement, as he considers that "we must necessarily draw a strong line

* Here the translator seems to have fallen into error; he says "cannot be logically placed," which is opposed to the whole argument.

of demarcation between man and the anthropoids," the chief reason for this being apparently the development of the brain in the former; the old and new world monkeys have an equal claim to separation, and this leads to the adoption of M. Broca's arrangement of the order Primates under five families, the first of which is formed by man.

M. Topinard next attacks a very difficult subject, namely, the specific unity or multiplicity of mankind. The greater portion of this section of his book is occupied by an excellent discussion of the physical and other characteristics of the races of man and a description of the methods of investigation employed by various *savants*. In his classification of races, which follows, he to a great extent discards the divisions into three or five great families which have so generally been adopted, regarding it as better in the present state of science to define a series of distinct types, and indicate their general relationships, leaving it to the future to group them, if it be possible, under larger categories. The difficulty of deciding whether these types are distinct species, equivalent to those recognized by zoologists in other groups, arises, according to the author, "from the confusion created by intermediate types, some due to crossing, others natural, and in a state of transition, such as we meet with in every degree in the animal series:" but if we take "simple general types, as the white, the yellow, and the black with woolly hair; or particular ones, such as the Scandinavian, the Semite, the Esquimaux, the Mongol, the Kaffir, the Bosjesman, the Negrito,' the differences separating them are as great as those between species of the same genus of Mammals. From this and other arguments the author concludes that "The HUMAN FAMILY, the first of the ORDER of Primates, is composed of SPECIES, or fundamental human races." We cannot help regarding this polygenistic argument as the weakest part of M. Topinard's book. In discussing such a question we have no right to leave out of consideration at all events the "natural intermediate types, in a state of transition" above referred to; and further, in the light of the transformist theory which M. Topinard seems inclined to adopt, we cannot realize the idea of "fundamental human races" possessing "primordial characters." The last chapter of the book is devoted to a consideration of the origin and genealogy of man, in which, as already hinted, the author adopts the prevalent transformist views.

In conclusion we may compliment Dr. Bartley on the manner in which he has performed his task. His translation reads admirably, and we have no doubt is on the whole very correct, but we have detected two or three places where he is evidently in error, although we have not the French original to refer to. One of these has already been pointed out; another occurs at p. 532, when, in a sketch of Häckel's genealogy of man, the adaptation to terrestrial life is said to have "ceased" instead of "commenced" at the sixteenth stage. At p. 22 there is the following passage:—"The Didelphs, one of the most correctly defined of the sub-classes, from being based on their *habitat*, have been displaced and abolished, most of them being classed with the *Edentata* or the *Rodents*, the remainder becoming a distinct order under the name of *Pedimana*." This may not be a mistranslation, but it is certainly unintelligible to a zoologist. But the funniest error of all is at p. 199, where the French word "désormais" figures as the name of an author!

AMERICAN SURVEY PUBLICATIONS.

THE most important work published by the United States Survey of the Territories that has appeared during the present quarter is Professor Leo Lesquereux's description of the "Tertiary Flora * of the Western Territories." In this splendid volume, which is to be regarded as the complement to his previous great work on the "Cretaceous Flora" of the same region, Professor Lesquereux describes nearly 330 species of plants which have been obtained from the great series of lignitiferous deposits spread over a vast portion of Western North America, extending certainly from New Mexico in the south to and beyond the northern boundary of the States. The true position of these lignitic beds was long a matter of dispute, seeing that in their lowermost deposits certain fossil animals of Cretaceous type had been found. From the researches of the late Professor Meek "On the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country" (see "Pop. Sci. Rev.," N.S. Vol. I., p. 79) it seems clear that in these lowest beds, immediately succeeding the series known as the Fox Hills group, the highest undoubtedly Cretaceous series, we have traces of a transition from Cretaceous to Tertiary conditions; but, considering the preponderance of the evidence from the fossil Flora, if a line is to be drawn between the two it must pass below the lignitic beds. It is in this sense, apparently, that Professor Lesquereux treats all the plants described in his present magnificent work as of Tertiary age.

It will be unnecessary here to refer in detail to the species described, most of which are new, although a few are identical with, and many related to European and Greenlandic forms. We may mention, however, that the author notices four species of parasitic Fungi (*Sphæria* and *Sclerotium*), and has also discovered traces of a Lichen which he refers to the genus *Opegrapha*. Four Lycopods are described, three of which belong to *Selaginella;* the Ferns belong to Tertiary types; and the total absence of *Gleichenia* is interesting in connection with the question of the age of the deposits. Among the Phænogams we find the usual Tertiary genera.

By his researches Professor Lesquereux has determined the equivalence of the different deposits over a wide extent of country, and has also been led to recognize four groups in the Lignitic formation of the Upper Missouri and Colorado regions.

The first or lowest group, from which, probably owing to its being most worked for fuel, 200 out of the 329 recorded species have been obtained, has only 16 species known to occur in higher Tertiary groups. Its flora includes nearly all the Ferns, Palms, Figs, Cinnamons, *Magnoliæ*, and Rhamneæ of the Lignitic formation. It is referred by the author to the Lower Eocene.

The second or Evanston group, from which only 34 species of plants are known, has 20 of these peculiar to itself. Its characteristic plants are five

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* "Report of United States Geological Survey of the Territories." F. V. Hayden, U.S. Geologist-in-Charge. Vol. VII. "Contributions to the Fossil Flora of the Western Territories." Part II. "The Tertiary Flora." By Leo Lesquereux. 4to. Washington: Government Printing Office. 1878.

Laurineæ and two *Araliæ;* the former possessing Miocene affinities; the latter having "the same degree of relation to Cretaceous types of Nebraska as to Pliocene species of California;" and its Miocene affinities are further witnessed by the presence of *Taxodium distichum miocenicum* and of *Populus arctica.* The species common to this and both the higher and lower groups are of Miocene type, but Professor Lesquereux says "This small Flora seems to represent a peculiar stage intermediate between the first and the third division," and further on he remarks that "according to Professor Cope's statement, bones of Eocene vertebrate animals have been found in connection with it," and seems inclined to regard it provisionally as Upper Eocene.

The third group, that of Carbon, is manifestly related to the Miocene both of Europe and Greenland, not only by the general facies of its plants, but also by the presence of numerous species such as *Platanus aceroides* and *Guillelmæ, Populus arctica, Taxodium distichum,* and species of *Acer, Betula, Quercus,* and *Corylus.* Palms are entirely wanting, not even the doubtful fruits (*Palmocarpon*) which occur in the second group being found here. Its probable age is Middle Miocene.

In the fourth, or Green-River group, we have the same predominance of unmistakable Miocene forms, but many of its species display still more modern relationships, and the author regards it as Upper Miocene. Of course the whole of these geological divisions are to be regarded as provisional and approximate only; they are, as the author says, "like the first outlines traced for the preparation of a map: they may be erased or modified; the spaces have to be filled as our acquaintance with the Tertiary becomes more intimate." The sequence of events indicated, as Professor Lesquereux thinks, by the result of his researches, as also his opinion upon the position in the geological series of Lignitic beds, as a whole, may be gathered from the following extract. He says, "I readily admit the facts, established from sufficient evidence, that a fossil Cretaceous fauna has left traces of its presence up to the very base of the Lower Lignitic measures, and that there the remains of a few invertebrate animals and those of one Saurian, all of Cretaceous types, have been found in connection with plants whose characters have been considered until now in Europe as representing a Tertiary Flora. Is the flora to decide the relation of age of the formation, or the Saurian bones of Black Buttes, with the few shells of brackish water, either found there, or which may be found hereafter in the same circumstances? The slow upheaval of a new land at and from the base of the Lignitic is sufficiently evidenced. . . . This land, which, rising up, is cut, of course, by shallow brackish swamps or estuaries, is the beginning of a whole formation of wide surface and great thickness, where the plants, preserving their Tertiary characters, have constituted the materials for the composition of the numerous coal strata, which constitute an essential part of it. In those brackish estuaries paleontologists have already recognized species of positive Tertiary relation, mixed with a few remains of Cretaceous types. But these low swamps drying up, their Cretaceous fauna is gradually reduced in its representatives by the influence of different atmospheric circumstances, while that of younger types becomes predominant. Henceforth the Cretaceous animals appropriate to deeper water may live still; their remains may even be found hereafter

mixed with Tertiary strata, but their presence cannot modify the age of the new land formations. This admission would be against reason quite as much as the assertion that we are now still living in Cretaceous times, because animals of Cretaceous type are dredged from the depths of the ocean."

With this extract we may conclude our notice of Professor Lesquereux's work, the value of which is enormously enhanced by the beautiful plates which illustrate it. These are 64 in number, and contain excellent figures of every species referred to in the text—a condition, indeed, which is absolutely essential to every descriptive book on fossil botany.

Next to Professor Lesquereux's Tertiary flora, the most important contribution that we have received from the Survey is the first part of the fourth volume of its Bulletin,* which contains no fewer than 14 articles, most of them of considerable interest. The majority are of zoological nature. Thus we have an interesting account of the birds of the Lower Rio Grande of Texas by Mr. G. B. Sennett, edited by Dr. Elliot Coues, devoted especially to a description of the habits and manners of the birds observed by the author, but including also many valuable notes on their characters by the editor. A new species of Tit is described under the name of *Parula nigriloba*, Coues. Another important ornithological paper is that by Mr. Ridgway on the American Herodiones, of which the first part here appears, containing a synopsis of the American genera of Ardeidæ and Ciconiidæ, with a monograph of the American species of the genus *Ardea*. The American forms of the group Herodiones are referred by the author to five families, the Cancromidæ (Boatbills), Ardeidæ (true Herons), Ciconiidæ (Storks), Ibididæ (Ibises), and Plataleidæ (Spoonbills). The Eurypygidæ or Sun-Bitterns, which are also an American group, are placed by some authors near the Rails, but Mr. Ridgway seems to think that they may nevertheless be Herodiones, although he does not include them in his synopsis. The monograph of the species of *Ardea* contains descriptions of four species, three exclusively American, and the fourth our Common Heron, which is said to occur occasionally in Greenland. Two new genera of herons (*Dichromanassa* and *Syrigma*) are proposed. The two American Storks, according to Mr. Ridgway, present a rather difficult question of synonymy, which we may recommend to the attention of our ornithological readers; for one of them the author has established the new genus *Euxenura*, characterized especially by peculiarities of the tail, and the remarkable development of the lower tail-coverts.

From birds we may pass to Mammals, under which head we have a series of notes, by Dr. McChesney, on the animals of that class observed by him at Fort Sisseten in Dakota, of which those relating to the Rodents are the most important. Dr. McChesney bears testimony to the recent disappearance of the larger Mammals under the pressure of advancing civilization. The most interesting communications on Mammalia, however, are two notes by Dr. Coues, on consolidation of the hoofs in the Virginian deer, and on a

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* "Bulletin of the United States Geological and Geographical Survey of the Territories." Vol. IV., No. 1. 8vo. Washington: Government Printing Office. 1878.

breed of solid-hoofed pigs, apparently established in Texas. To these papers we shall refer in our "Summary."

The reptiles of Dakota and Montana furnish the subject of an article by Dr. Coues and Dr. H. C. Yarrow, which includes descriptions of a series of species such as makes our British Reptile Fauna appear very insignificant, although, as it includes two rattlesnakes, the colonists of these western Territories are perhaps not much to be envied for this pre-eminence.

The remainder of the zoological articles relate chiefly to insects and, indeed, to the single order Lepidoptera. Mr. Chambers describes a considerable number of new species of Tineina, chiefly from Texas, although a few from more northern localities are interspersed; and follows up this paper with a classified catalogue of the plants on which these small moths are known to feed in the United States and Canada, and this again with an index to the described Tineina of the same countries. This last will prove a most valuable aid to entomologists. Mr. Grote describes numerous new species of Noctuid Moths, chiefly from California, and furnishes notes on some other species; and Mr. Scudder has a short notice of the Butterflies collected by Dr. Edward Palmer, in the arid regions of southern Utah and northern Arizona, during the summer of 1877, which also includes descriptions of new forms.

Carcinologists will be interested in an article by Mr. J. S. Kingley on the North American species of the genus *Alpheus*, to the number of which the author adds considerably, perhaps too liberally, considering the amount of materials at his command. *Alpheus minus* and *heterochelis* of Say, and four of the author's new species, occur on both sides of the Isthmus of Panama, and the author gives a list of all the species of Decapod Crustacea that he knows of as being reported from both coasts. There are 26 in all.

The remaining articles relate to palæontological matters. In one of them Professor Cope describes some fossil fishes from the Cretaceous and Tertiary deposits west of the Mississippi; in the other he takes up the cudgels in defence of his order Pythonomorpha, and in opposition to the views expressed by Professor Owen as to the affinities of the Mosasauroid reptiles on which that order was established.

Dr. Hayden's Preliminary Report on the Field Work of the Survey under his direction in the season of 1877* is a record of persevering activity which promises most important and interesting results. Considerable progress was made in the survey of parts of Wyoming, Idaho, and Utah, and various geographical and geological details are here briefly indicated, the principal report being that of Mr. O. St. John on the geology of the Teton district, which appears to display very interesting but rather complex characters. Dr. C. A. White, the palæontologist to the survey, has made some extensive journeys in various directions for the purpose of investigating on the spot the palæontological characters of various formations in districts which have been surveyed, or are now in course of surveying. Besides demonstrating the identity "of the lignitic series of strata east of the Rocky Mountains in Colorado, with the Fort Union group of the Upper Missouri River, and also

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* "Preliminary Report of the Field Work of the U.S. Geological and Geographical Survey of the Territories for the season of 1877." 8vo. Washington: Government Printing Office. 1877.

with the great Laramie group of the Green River Basin and other portions of the region west of the Rocky Mountains," he found "the planes of demarkation between any of the Mesozoic and Cenozoic groups, from the Dakota to the Bridger inclusive, to be either very obscure or indefinable; showing that whatever catastrophal or secular changes took place elsewhere during all that time, sedimentation was probably continuous in what is now that part of the continent from the earliest to the latest of the epochs just named," a conclusion perfectly in accordance with that indicated in connexion with Professor Lesquereux's work. We have a notice here of the discovery, by Messrs. Scudder and Bowditch, of very rich deposits of fossil insects in the Tertiary Basin of Florissant, Colorado, where Mr. Scudder estimates that the insect-bearing shales, "have an extent at least fifty times as great as those of the famous locality at Œningen." Many thousand specimens of insects and plants have now been received from Florissant, and others are being sent in from another new locality in Wyoming; the whole will form the materials for a most interesting volume of the Records of the Survey. Professor Leidy's investigations of the Rhizopods, and the researches of Sir Joseph Hooker and Professor Asa Gray on the botany of the region, are briefly referred to; as also the investigations that have been made by officers of the Survey of the singular cliff dwellings and towns of the ancient inhabitants of New Mexico and Arizona, models of the more interesting of which are being prepared on a considerable scale.

We do not know whether we should be right in crediting the Survey with the production of a "Palæontological Bulletin,"* two numbers of which we have received from Professor Cope. They contain descriptions of vertebrate fossils chiefly from Secondary and Tertiary deposits of the western Territories, and are evidently advance-copies of communications to the American Philosophical Society, issued for the purpose of securing priority. With this view one number is said to be "Published December 10, 1877," and the other to be "Printed January 12, 1878." It is melancholy to see the struggle for priority prompting good men to such futile devices; these books are *not* published, for the very essence of publication consists in the thing published being procurable by any student who may hear of its existence. If our American friends will persist in racing each other with their descriptions, why don't they adopt the simple method of making the issue of their pamphlets a real publication, by simply having a bookseller's name and address on the title page? If they wish to limit the circulation of their productions they can easily do so by placing a high price upon them, as Her Majesty's Geological Survey has lately done with distinguished success.† The two numbers before us of Professor Cope's "Bulletin" contain papers on New Vertebrates from

* "Palæontological Bulletin," Nos. 27, 28. 8vo.

† In saying this we do not wish to reflect upon the officers of the Geological Survey, knowing well that the absurd prices which have been put upon the recent publications of that most valuable institution have been adopted at the dictation of an office under whose thumb the insane method of managing such matters in England has in this respect placed the control of the Survey's action. It is quite natural that a Stationery Office should contain a plentiful supply of red tape, but it is rather hard that its clerks should be allowed to employ that commodity in choking one of our few scientific departments.

the Upper Tertiaries of the West (Mammals, Chelonians, and Fishes), on New Saurians from the Trias of Pennsylvania, and on the Vertebrata of the Dakota epoch of Colorado. In the first the most interesting species noticed are *Pithecistes brevifacies*, a monkey? and *Tetralophodon campestre*, the latter the second North American species of its genus. The Triassic Saurians include new species of *Thecondotosaurus* and *Palæosaurus* and *Suchoprion aulacodus*, Cope; and the third paper contains descriptions of *Camarasaurus supremus*, *Amphicœlius altus* and *latus* (the latter two reprinted from No. 27!), *Symphyrophus musculosus* and *Caulodon leptoganus*, with notices of some other species.

WHITE'S SELBORNE.*

WHAT is the source of the perennial charm that seems to invest Gilbert White's "Natural History of Selborne?" a book which can probably count more editions, or rather reprints, than any other original work, not purely of literary interest, except perhaps Walton's "Complete Angler." It is evidently not solely for the sake of the natural history observations contained in it that this book has been the delight of old and young ever since its appearance; for, valuable as White's observations are, the student may get most of them in a more systematic form, and combined with those of other naturalists in the various books upon special departments of British zoology, which have appeared of late years. We must seek elsewhere for the cause of the continued popularity of the "Natural History of Selborne," which it seems to us is to be found rather in the mode in which the various subjects treated of are presented to the reader, than in the intrinsic value, great as this may be, of the materials of which it is composed.

In fact, as in the case of Walton's "Angler," already referred to, although not to the same extent, it is the workmanship that gives much of its value to the author's production. Thousands have read Izaak Walton's book who never intended to wet a line; and in like manner, thousands have read the "Natural History of Selborne" without feeling any particular interest in its natural history, or desire to be converted into naturalists by its perusal. The source of the popularity of the book is to be found in the charming manner in which the author has given the results of his observations on the objects surrounding him, and in the genial humour which breaks out from time to time and illuminates his pages.

In thus maintaining that it is chiefly as a literary performance, as the work of a man of genius, that White's "Selborne" has retained its hold upon the British public, we would not be understood to speak slightingly of its merits as a natural-history book. On the contrary, so admirably careful was White in all his researches, so open was his mind to the reception of all opinions connected with his favourite studies, and so enthusiastic was he in their prosecution, that even in this respect his book may be held up as a

* "The Natural History and Antiquities of Selborne, in the county of Southampton." By the late Rev. Gilbert White, formerly Fellow of Oriel College, Oxford. Edited by Thomas Bell, F.R.S., F.L.S., F.G.S., &c., Professor of Zoology in King's College, London. 2 vols. 8vo. London: Van Voorst. 1877.

model for all field-naturalists, although we fear that few are capable of following in his footsteps. We have, indeed, dwelt so strongly on the literary charms of the book, on the genius which, by a series of letters beautiful in their seemingly unstudied simplicity, has rendered the name of an obscure Hampshire village a household word wherever the English language is read, because this great element of its popularity seems generally to have escaped the penetration of its numerous editors. Nearly all the leading popular zoological writers of the last fifty years have tried their hands upon an edition of White's "Selborne," and most of them have overlooked the characteristic of the work to which we have above alluded, and taken White's text simply as a peg on which to hang notes embodying all they knew or could scrape together upon any subjects mentioned by him. Hence most of the editions are overloaded with notes, which, whatever may be their intrinsic value, have certainly the inconvenience of too frequently diverting the reader's attention from the text.

In Mr. Bell's edition, just published, this is not the case. The venerable editor, who has resided for many years in White's own house at Selborne, has evidently appreciated justly the artistic merit of the book, and as he tells us in his preface his object in the notes appended to this edition "has not been to treat at large on the general history of the various objects referred to . . . . but, rather to render as correct and complete as lay in his power the text of Gilbert White, with such additions and modifications as have been observed in the district since the first publication of his work." Thus the notes, several of which are borrowed from previous editions, are almost entirely such as serve to supplement the text, to correct certain errors into which the author had fallen, and to elucidate points which he left doubtful, the particulars recorded being in most cases founded on local observations for which the editor's long residence on the spot has given him abundant opportunities, and serving literally to complete the "Natural History of Selborne."

White's original work, including both the "Natural History" and the "Antiquities of Selborne," furnished with notes as above described, and accompanied by the Naturalist's Calendar, Observations on Various Parts of Nature and other documents of White's annotated by Markwick, occupy the first volume of Mr. Bell's edition. Of this we need only say that we have in it a careful reprint of the original text, accompanied, as already stated, by very valuable notes selected solely as completing or emendating White's work. This the editor has prefaced with a short memoir of Gilbert White, in which, as might be expected from the even tenour of his life, the sensational element is entirely wanting. White lived for the greater part of his long life on the property which he had inherited from his father at Selborne, where he was contented with officiating as the curate of a non-resident vicar, refusing various offers of college-livings which would have drawn him away from the district in which he delighted, and which his labours have made familiar to the whole civilized world.

Mr. Bell's object, however, in preparing this edition, was to raise as fair a monument as possible to the memory of the illustrious naturalist of Selborne—to give the clearest possible picture of Gilbert White and Selborne. With this view he has printed in his second volume all the extant corre-

spondence of Gilbert White, and we have here a long series of letters written by him to various members of his family and to the naturalists with whom he corresponded, many of whose replies are also printed. These letters are of great interest from several points of view. Many amusing little revelations of social conditions occur in them from time to time; some of them worthily supplement the text of the "Natural History of Selborne," among which we may specially note the correspondence, chiefly on trees and arboriculture, with Robert Marsham, of Stratton Strawless, in Norfolk (an F.R.S. who writes in the first person singular with a little "i"); and above all they let us further into the character of White himself, showing more and more clearly the amiable, genial character of the man, his quiet and gentle humour, his love of all knowledge, and his readiness to pour out for the benefit of others whatever stores he had himself accumulated.

From a zoological point of view we may indicate as particularly interesting the letters to his brother, the Rev. John White, chiefly relating to a fauna of Gibraltar, which the latter was engaged in preparing from collections and observations made by him while officiating as a chaplain in that fortress. The death of John White, before the difficulties of coming to terms with a bookseller had been surmounted, unfortunately prevented the publication of this book; but the correspondence between the two Whites, and between John White and Linnæus, will be found most interesting by those naturalists who have time to spare for the history of biological studies. We have in them a faithful reflex of the kind of investigations which only a hundred years ago occupied the attention of our predecessors; we find the system of the great Swedish naturalist represented as actually struggling to get a footing in England, where some years later it was so firmly established that a late distinguished naturalist is said to have been excluded from a learned Society because he had advocated the adoption of the Natural System in Botany, and we have heard of an entomologist who destroyed all specimens which, as he said, were "not in Linnæus;" and the references to books and discussions of their contents have a strangely antiquated tone about them to our modern ears.

The correspondence is followed by a letter "On the Sense of Hearing in Fishes," which was evidently intended to have formed part of the series constituting the "Natural History;" and this again by a sermon giving us a sample of White's mode of preaching, and, as the editor says, "of the ordinary character of the best village sermons of the period," a plain and simple discourse, directed chiefly to the improvement of the moral condition of the hearers.

After the sermon comes one of the most amusing items in this volume, namely a literal reprint of an account of expenses incurred by Gilbert White, for about two years, during part of which he held the office of Proctor in the University of Oxford. Mr. Bell says of it that it has always struck him "as exhibiting in its simplicity that combination of genial kindliness and generous hospitality with habitual prudence, punctilious formality, and methodical habits which was so characteristic of the whole of his after-life. As an indication of some phases of ordinary college life of the time, it is not without some amusing interest." The first thing that

strikes one on inspecting it is the peculiar filling up of all three money columns in every instance; thus White writes that he paid for—

"Two Sevil-oranges . . . . . 00 00 03;"

and on another occasion that he—

"Gave Jenny Croke a round China-turene,
"Being prevented paying for y^e^ post-chaise . . . 01 03 11"

Certain items will excite the envy of some people in the present day; for example we have one day—

"Oysters . . . . . 00 00 02;"

and another—

"Oysters . . . . . 00 00 03*d.*"

Lovers of oysters would be puzzled to get any appreciable quantity of their favourite mollusc for such sums nowadays. Life in Oxford was probably very jolly in White's time, and he seems to have gone in pretty freely for the festivities of the place, the numerous tips to "Mrs. Croke's Man," "Dr. Bristow's Man," &c., being, no doubt, so many records of good dinners or other entertainments. A frequent item in the account is "Lost at Cards," but the amounts show that the gambling was not carried to a ruinous extent, eighteenpence being, we think, the extreme amount of White's losses on any one occasion. On one day we find, "Lost at Goose, 00 00 06*d.*," but this seems to have been at Selborne, probably in a family party. A curious item occurs on April 20, 1752, namely:—

"Present to the Vice-Chan. a Loaf of Double
Refined Sugar 7lbs. at 13*d.* . . . 00 07*s.* 07*d.*
With six bottles of Wine."

This appears to have been an official present on taking office. Another connected with the same incident is "An 100lb. weight of biscuits to treat the Masters of Art in Oriel Hall;" this rather dry treat was, perhaps, to be moistened with some of the "six doz. of mountain-wine, very old and good," that figures in the account four days previously. Olives seem to have been important elements of conviviality. White bought them first of all in plates varying in price from a shilling to half-a-crown, but probably found these retail purchases too expensive, for, subsequently, we find him getting his olives in bottles from London. The olives, apparently consumed with punch, appear repeatedly in the account, generally for the entertainment of visitors—thus his cousin, "Bappy Isaac," figures two or three times in connection with that beverage, as also do the Mulsos, father and son, for whose refreshment we find five-shillings' worth of punch charged. This exuberance of hospitality in behalf of these last gentlemen may have had its origin in White's affectionate remembrance of Miss Mulso, for whom he had a *tendresse* in early days. The lady, however, preferred a rival, and is well known in literature by the name of Mrs. Chapone. Occasional references to tavern dinners and other jollifications of the same nature occur, and, altogether, we may infer that the Junior Proctor in the University of Oxford, in 1752–53, spent a tolerably merry time when his duties called him to that city. Other items serve to throw more or less light upon various social matters, espe-

cially the mode and cost of travelling, the rate of wages, &c., in the middle of the last century, but for these we must refer the reader to the original work.

The remainder of this volume is occupied by a "Garden Kalendar," kept by White at Selborne, a description of a fire-escape invented about 1788 by a Mr. Dufour, and tried against the front of Benjamin White's house in Fleet Street, and some supplementary matter. The latter includes lists of the most noteworthy animals and plants observed in Selborne and the neighbourhood, compiled, with assistance, by the editor; a very short note on the geology of Selborne by Mr. William Curtis; and an appendix by Lord Selborne, on the Roman-British Antiquities of the parish, the last relating chiefly to a find of nearly 30,000 coins of various emperors, from Gordian the younger to Allectus (A.D. 238–296), found here in 1873. From this and other evidence Lord Selborne believes that in the basin of Woolmer Forest we have the scene of the final overthrow of the British Army under Allectus.

The illustrations, which are not numerous, consist chiefly of steel plates of houses and views about Selborne, rendered interesting by being referred to by White. The appendix on the antiquities of Selborne is also illustrated with a coloured plate showing some curious mediæval (thirteenth century) tiles found in Selborne Church during its restoration.

We cannot conclude this notice, already, perhaps, rather too long, without congratulating Mr. Bell on the completion of what we know has been to him a labour of love, but, nevertheless, a labour, the last stages of which, at all events, must have been irksome enough to one who has long since passed the Psalmist's allotted period of human life. That he has done his work well, and with a true appreciation of the merits of his author, we have already endeavoured to show, and we can only hope that he may have good evidence that the reading public are interested in the result.

THE *POLARIS* ARCTIC EXPEDITION.*

THE expedition of the U.S. ship *Polaris*, which left Washington on the 20th June, 1871, and of which this handsome volume gives the history, was as successful in its early career as it proved to be unfortunate in its termination. Its Commander, Capt. C. F. Hall, was in every way fitted to undertake the charge of the expedition, having had great experience in Arctic travelling, and having, moreover, spent nearly eight years amongst the Esquimaux. Living with them in their houses, and following their mode of life, he had gained a knowledge of their language, and an insight into their customs, which could not but have proved of the greatest service to him in the arduous task he had set himself of planting on the Northern Pole of our hemisphere the stars and stripes of the United States. To his representations to the Government, and to enthusiastic lectures in many parts of the States, was due the appropriation of 50,000 dollars, granted

* "Narrative of the North Polar Expedition. U.S. Ship *Polaris*, Captain Charles Francis Hall, Commanding." Edited by Rear-Admiral C. H. Davis, U.S.N. 4to. Washington. 1876.

by the American Senate for furthering the progress of Arctic exploration, and for the discovery of the North Pole; and by his energetic exertions, the *Periwinkle*, afterwards christened the *Polaris*, was fitted and equipped for the voyage in a manner more complete than had ever before been accomplished. Besides the ordinary ship's officers, the expedition took out men of science qualified to report upon the Natural History, Meteorology, and Geology of the region visited, and to observe such Astronomical phenomena as might present themselves, the scientific staff being under the direction of Dr. E. Bessels.

Capt. Hall had at first contemplated proceeding by Jones' Sound, but subsequently found cause to abandon this intention, and eventually steered his course for Smith's Sound, which he reached on the 28th August, and which he found, contrary to all previous experience, quite free from ice. On the next day he reached his highest sailing point, which was afterwards determined by the U.S. Hydrographic Office to be in lat. 82° 11′ N. Here it was that the troubles of the expedition fairly commenced, and the *Polaris*, beset by ice, was drifted towards the south until she was finally brought to anchor in a bay subsequently named "Thank God Harbour," in lat. 81° 38′ N. From this place Capt. Hall made what unfortunately proved to be his last journey towards the north, travelling a little beyond Cape Brevoort in about the 82nd degree of latitude, on his return from which he was attacked by sickness, which terminated fatally on the 8th November, 1871, when the command of the expedition devolved upon Capt. Budington and Dr. Bessels conjointly, and under their charge various sledge and boat journeys continued to be made or attempted towards the north.

With the summer of 1872 efforts to reach a higher latitude in the *Polaris* were renewed; and though she had received severe injury from the "nips" to which she had been subjected, and when sawn out of the ice leaked so badly that it was necessary to keep the pumps constantly at work, she was got under way, but failing to make progress she returned to "Providence Berg," a stranded iceberg of large size, which afforded considerable protection to the ship when anchored under its friendly shelter.

At length, further progress towards the north being deemed impossible, the commanders reluctantly determined to make their way south, and finally left their harbour of refuge on the 12th August, 1872, having then in the bunkers only coal sufficient for six days' steaming. Constantly encountering close and impenetrable packs, the *Polaris* was at last moored to a large floe, with which she continued to drift, and on which a store-house was erected and a large quantity of provisions deposited in case of accident to the ship. Before this labour was brought to an end the high winds of early spring arose, which, breaking up the already weakened ice, forced the ship away from the party at work near the store-house, leaving a large part of the crew and many Esquimaux afloat upon the large floe, or upon smaller ones in its immediate vicinity. The *Polaris* continued to drift, chiefly in a southerly direction, until in the middle of October she was driven ashore, when the party on board forsook her, and passed the winter in a hut which they built on land; in June of the following year they once more set out on their return journey in boats which had been built by one of their party, and three weeks afterwards were picked up by the *Ravenscraig*, which carried the rescued crew to America.

Left alone at the mercy of the winds and waves, with boats which they had little or no opportunity of using, and with a supply of provisions so small and precarious as to render the utmost care imperative, the position of the unfortunate party on the floe, consisting of nine of the *Polaris'* men, and ten Esquimaux, appeared almost hopeless. At times remaining stationary, at others moved backwards or forwards by the ever-varying winds and currents, with ice on every side of them packed so closely that progress in the boats became impossible, almost without wood for fires, and presently so short of provisions that uncooked seal meat, with the skin and hair attached, was greedily devoured, and the men on watch were so demoralized by want and privation that they stole from the small remaining stock of food, while their comrades endeavoured to forget in sleep the perils of their situation, nothing was needed to increase their despair and hopelessness, when, in the spring of 1873, the ice began to break up and the miserable party found themselves on the mere remnant of the immense floe upon which they had taken refuge. For more than a month they remained in this situation, hesitating whether to trust themselves to the ice-floes which were now occasionally washed by the sea waves, or to their only remaining boat, when on the 27th April their hopes were raised by the sight of a steamer, which appeared to acknowledge the signals of the sufferers, but which did not in fact perceive them, and disappeared in the darkness, leaving them for two more weary days to the mercy of the elements, when they were observed and rescued by the *Tigress*, on the 30th April, and were carried back to civilized life.

Being only a record of the progress of the expedition, taken from the various journals of the different members of the staff, there is little of a definitely scientific nature in this work, but the narrative is clear, and in the main interesting, though savouring somewhat of official red-tape. It is illustrated by numerous maps and engravings, the latter of which are well executed, and convey to the mind a most vivid realization of Arctic scenery. We have already had occasion to speak in high terms of the admirable manner in which works published by the American Government departments are got up; and this is no exception to the rule: the type, printing, and paper are all excellent, and if the book is at times perhaps a trifle uninteresting to the general reader, owing to the minuteness of detail, it may on this account prove of all the more service to future explorers in Arctic regions, conveying a true, if not a very lively, idea of the difficulties which are met with, in language which, if it cannot be commended for absolute elegance, is, at least, free from affectation, and from the high flown or "slangy" style too common amongst authors on the western shores of the Atlantic.

THE BARENTS RELICS.*

THE translation of Mr. De Jonge's report upon the relics of the Arctic Explorer, William Barents, lately recovered by Mr. Gardiner, from Nova Zembla, with a brief explanatory preface by the translator, Mr. Van Campen, has produced a little volume of considerable interest, not only to

* "The Barents Relics: recovered in the Summer of 1876, by W. C. L. Gardiner. Described and explained by J. K. J. De Jonge." Translated, with a Preface, by S. R. Van Campen. 8vo. Trübner & Co., London, 1877.

geographical, but, perhaps more particularly, to historical students. Mr. Van Campen gives a short account of the expedition of Barents and Heemskerck, which set out from Amsterdam as early as the year 1596, having for its object the discovery of a northern route to China, but which was forced, by stress of weather, to fix its winter quarters on the inhospitable shores of Nova Zembla, where a hut was erected, from which, after a lapse of almost three centuries, many interesting remains have been recovered, and brought back to the fatherland of the adventurous Hollanders. Amongst these relics is a "scroll" signed by Barents and Heemskerck, giving a brief account of the objects of their voyage, and relating the hardships to which they had been subjected; and the dilapidated remains of several books, both printed and in manuscript, from which, however, little further information of the travellers can be gleaned. The printed books, which are for the most part collections of songs of a religious and sentimental character, are nevertheless of interest as indicating the means by which, no doubt, the hardy Dutchmen tried to while away the tedium of their long imprisonment. Besides these, there are many domestic utensils, and a "package of tallow candles, eighteen in number, consisting of nine to the pound; undoubtedly the oldest candles in the world—still they are able to give light."

One result of the observations of Mr. Gardiner, or rather of his predecessor in discovery, Captain Carlsen, has been very considerably to alter the geographical position of the north-east point of the island of Nova Zembla, which was found "to extend upward between 66° 31′ and 69° E. long., instead of lying in 76°, as was laid down in the latest charts." A map showing this change, and also a fac-simile of the "scroll" above referred to, are inserted in the book.

SCIENCE AND THE STATE.*

SOME weeks ago a series of extracts from a discourse delivered at Munich, by Professor Virchow, was published in the "Times," and attracted a good deal of attention. Mr. Murray has now published a translation of the entire discourse, which we cannot but regard as a most important and opportune expression of opinion on the part of one of the greatest of German *savants*.

This discourse has been regarded by many as a knock-down blow to the doctrine of evolution. It is, however, nothing of the kind; indeed it can hardly be said to be written in opposition to that doctrine, the admissibility of which, in some particulars, would seem to be accepted by Professor Virchow. We may refer more particularly to the reference at page 62 to the occurrence in North America of the "fossil ancestors of our horses, in regions where the horse itself has long since entirely disappeared;" and in other places the probability of the origin of organic forms by a process of evolution is distinctly admitted.

What Professor Virchow set himself to do in this discourse was simply to enter a protest against the doctrine of evolution (*die Descendenztheorie*), being regarded as founded upon a secure basis. He considers it to be still

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* "The Freedom of Science in the Modern State." By RudolphVirchow, M.D. 8vo. London: John Murray, 1878.

in the position of a hypothesis wanting proof, and objects strongly to its acceptance as an established theory, and especially to the consequences which have been drawn from it as such by the monistic philosophers of Germany; consequences which, as we all know, tend completely to revolutionize all our ideas and practically amount to the establishment of a new religion and a new philosophy. His protest, in fact, which was called forth by discourses delivered on previous days by Professors Häckel and Nägeli, and by Dr. Klebs, is, as he himself tells us, a "protest against the attempts that are made to proclaim the problems of research as actual facts, the opinions of scientists as established science, and thereby to set in a false light, before the eyes of the less informed masses, not merely the methods of science, but also its whole position in regard to the intellectual life of men and nations." Such a course, especially if the doctrine be expanded to the extent advocated by Professor Häckel and others, would, he holds, endanger that freedom of scientific opinion of which Professor Häckel's own discourse furnished a most striking example; and he considers that the teaching of such opinions in the schools as established truths, which was advocated by Professor Häckel, is very much to be deprecated.

We must confess that we perfectly agree with Professor Virchow in his general argument, and more or less in the opinions which he expresses upon the subject of evolution, which he regards as still an open question, but undoubtedly as possessing strong *primâ facie* claims to acceptance. In these days we have got beyond the old scholastic reasoning, according to which a philosopher established his own theory by the mere fact of demolishing his opponent's, and we can admit that a cause may have right on its side although its champion has weak places in his armour which he is not sufficiently skilful of fence to defend from the blows of his adversary. Professor Virchow endeavours rather to indicate some of these weak points than to invalidate the doctrine of evolution; but at the same time he objects strongly, in the interests of science and not of theology, to the extreme dogmatism displayed by some of the most advanced evolutionists, who would have us believe that the origin, not only of organic forms but of the universe itself, has been fully explained. The translation appears to be remarkably well done.

THE VERTEBRATES OF AMERICA.*

WE have received from Professor Marsh a copy of a discourse on the Introduction and Succession of Vertebrate life in America, delivered by him before the American Association for the Advancement of Science, in August last. It is manifestly impossible within the compass of a single lecture to discuss in anything like detail a subject so vast, but Professor Marsh has succeeded in sketching out, in a most interesting fashion, the leading events in the history of the vertebrate type in America, where, as is well known, some sections, especially, of that sub-kingdom, are represented by an astonishing abundance and variety of remains. Professor Marsh definitely accepts the theory of evolution, and endeavours, where possible, to indicate the probable lines of descent of the great groups of vertebrates.

* "Introduction and Succession of Vertebrate Life in America." By Professor O. C. Marsh. 8vo., 1877.

SCIENTIFIC SUMMARY.

ANTHROPOLOGY.

Shell-Mounds in Japan.—Professor E. S. Morse has communicated to the Boston Society of Natural History an account of an ancient shell-mound discovered by him at Omori, near Tokio, in Japan. In general the deposit resembled those described by Steenstrup, in Denmark. The implements found in it were mostly of horn; only three rude stone implements were discovered. The pottery showed a remarkable variety of ornamentation, though it was very rude in character. In the incised character of the markings it recalls the pottery of the east coast of the United States; whilst in the raised knobs for handles, on the edge of the vessels, it shows the closest resemblance to pottery discovered by Professor Hartt, in Brazil. Professor Morse was uncertain whether these are traces of early Ainos, or of a race which preceded the Ainos and was displaced by them during their occupation of the island from the north.—*Silliman's Journal*, February, 1878.

The Language of Deaf Mutes.—At the meeting of the Anthropological Institute on March 12, Professor A. Graham Bell read a paper "On the Natural Language of the Deaf and Dumb." He regarded dumbness as, in most instances, a consequence of deafness, arising not from any defect in the vocal organs, but from an inability to acquire articulate language due to the want of the means of imitating it. He said that the dogma "without speech, no reason," was well founded, for deaf-mute children think in pictures, from which they form a language of signs, which, as contractions of it become understood, develops into a conventional language, but this is always very limited. No deaf-mute has been found who had formed the idea of a Supreme Being. About the commencement of the present century the Abbé de l'Epée established an institution for the education of deaf-mutes, and the tendency of the instructions there given was to render the language more and more conventional by means of contractions. The result of systematic education has been to enable the deaf-mutes to form a community among themselves, employing a real language capable of representing abstract ideas as well as objects, and even possessing peculiar idioms of its own—for example, the objective case is placed first, thus: "the boots made the bootmaker." This is a difficulty, and perhaps due to a mistake in the education, but it furnishes an interesting subject for anthropological inquiry into the analogy with the development of spoken language. The North American Indians have a sign language, but less developed than that of the deaf-mutes. The language of the deaf-mutes is beginning to split into dialects.

ASTRONOMY.

Transit of Venus in 1874.—As we anticipated, Mr. Stone, Astronomer Royal at the Cape, does not accept the result deduced from the observations of the last transit by the Astronomer Royal for England. He has, in fact, obtained from the same series of observations, dealt with in a different manner—that is, interpreted differently—a solar parallax of about 8″·89, corresponding to a mean distance somewhat less than 92 million miles, or less than the result obtained by Sir G. Airy by nearly 1½ million miles. At a recent meeting of the Astronomical Society it was stated that Capt. Tupman had obtained precisely the same result as Mr. Stone by a particular interpretation of the observations made in December 1874. It is not, however, to be inferred that on this account Capt. Tupman either accepts Mr. Stone's estimate, or entertains any doubt as to the validity of the result obtained, nominally by Sir G. Airy, but in reality by himself, from the British transit operations of 1874. On the contrary, Capt. Tupman's announcement was intended as a jocular way of intimating how little reliance could be placed on Mr. Stone's estimate. But certainly the joke was one which told in two ways; and in the minds of those who are not prejudiced in favour either of Mr. Stone's views or Sir G. Airy's, will be held to show that almost any value between the limits of about 91½ million and about 94½ million miles can be obtained from the observations, according to the manner in which they are interpreted.

Distribution of the Fixed Stars in Space.—Mr. Sidney Waters has contributed a valuable chart to the proceedings of the Astronomical Society, representing the results of Sir J. Herschel's star gauges of the Southern Heavens, given in his Cape of Good Hope observations. The chart is on the equal-surface projection. The map was divided into 20 minutes in R.A., and 3° in P.D.; and the results of the gauges figured in their proper places; the areas of the spaces were calculated, and the average of the gauges falling on each space multiplied by its area, the result being dotted as nearly as possible equably over the space. Nearly all the spaces were covered in this way; but in those cases where no gauges fell the average of the surrounding spaces was taken. The number of stars marked in the map is very small compared with the number actually existing, but the chart represents with sufficient accuracy the distribution of stars over the Southern Heavens down to the faintest stars visible in Sir John Herschel's 18¼-inch reflector. The stars visible to the naked eye were afterwards added. "The teaching of the chart," says Mr. Waters, "does not confirm the results of Mr. Stone's investigations, published in the 'Monthly Notices' of last March. The great massing of stars in parts of the Milky Way, its complicated form, and the sudden decrease of stars at its borders, are facts not consistent with the view that we are merely looking through an immense depth of stars, or that distance is the principal reason of their faintness. It is not denied that brightness is an important factor in the determination of stellar distances; but the point contended for is that it is not a sufficient basis upon which to found any theory of the construction of the heavens. The fainter stars increase at a far greater rate than would be the case if Mr. Stone's view were correct;

and the theory that the stars are distributed with any uniformity, either as to space or dimensions, is not in accordance with the teaching of that chart which I now beg to lay before the Society." The results obtained by Mr. Waters, in fact, confirm very effectively the views indicated by Mr. Proctor. By the way, we have been asked whether at p. 98 of our last number, correct dates are assigned to Mr. Proctor's papers on stellar distribution, as, if so, *he* cannot have borrowed from *M. Flammarion.* "It will go near to be thought so, shortly." The dates are correct.

Cyclonic Arrangement of the Solar Granules.—The splendid solar photographs taken by Dr. Janssen at Meudon show among other interesting features a tendency of the solar granules to arrange themselves in a spiral form, accompanied by more or less loss of distinctness of outline of the individual granules, an appearance suggesting great cyclonic disturbance of the part of the solar atmosphere in which these bodies lie. Mr. Huggins puts on record a similar appearance observed by him telescopically in 1866. His notes, made at the time, run thus: "Saw distinctly the granules. A spiral band of closely associated granules, ending in one of larger size. In one area near the centre of the sun's disc the granules appeared more elongated than usual, rather sparsely scattered, and the larger diameters very nearly in the same direction. In neighbouring areas the granules were smaller and less elongated. Amongst these no general direction was observed."

The Bright Line Spectra of Irresolvable Star Clusters.—Mr. Stone gives an explanation of his remarkable paper on this subject (recently communicated to the Royal Society), from which it appears that Professor Stokes and Messrs. Huggins and Proctor altogether misapprehended the purport of Mr. Stone's communication. His earlier statement ran thus: "The sun is known to be surrounded by a gaseous envelope of very considerable extent. Similar envelopes must surround the stars generally. Conceive a close stellar cluster. Each star, if isolated, would be surrounded by its own gaseous envelope. These gaseous envelopes might, in the case of a cluster, form over the whole or a part of the cluster a continuous mass of gas. So long as such a cluster was within a certain distance from us, the light from the stellar masses would predominate over that of the gaseous envelopes. The spectrum would, therefore, be an ordinary stellar spectrum. Suppose such a cluster to be removed further and further from us. The light from each star would be diminished in the proportion of the inverse square of the distance; but such would not be the case with the light from the enveloping surface formed by the gaseous envelopes." And so forth. It was mistakenly supposed by the trio above named that Mr. Stone was here referring to effects produced by varieties of distance; but it appears he was considering really the effects of the physical aggregation of such clusters. "The clusters which I had under contemplation were physical clusters, and this isolation of the gaseous surroundings would be, under suitable conditions, destroyed by the relative gravitation and heating effects of the several members of the system. It is to such a cluster only that my reasoning applies; and I think such will be seen to be the case if my paper is carefully read,"—"between the lines," he should have added. We would not for a moment question Mr. Stone's statement that his meaning was that which he now indicates. There can be nothing more discourteous and there are few things more unjust than to

question the explanation which a writer offers of his own words. But it must, we think, be conceded that Professor Stokes and Messrs. Huggins and Proctor had some reason for understanding Mr. Stone's paper as they did, and that among the many excellent scientific qualities possessed by the Astronomer Royal at the Cape, the power of clearly and unmistakably indicating his meaning must not be included.

Specular Reflexion from Venus.—Mr. Christie, assistant observer at Greenwich, continues to surprise students of science by the support which he gives to certain utterly preposterous notions respecting the celestial planets, which have been advanced of late by an admirable landscape painter, who seems very little acquainted with astronomical and optical laws. He now advocates the theory that Venus has a surface not merely possessing the power of reflecting light specularly, but also having metallic brightness and hardness. Although this theory is one of those which not only cannot be accepted but cannot seriously be attacked (standing somewhat on the footing of the older absurdity that the moon is made of green cheese, a theory never yet oppugned to the best of our belief), yet it seems to us that the observation on which the absurdity has been based is worthy of attentive consideration. It is this, that the brightest point of the disc of Venus, when the disc of the planet is gibbous (and recently the same has been found to be the case when the disc is crescent-shaped) lies within the limb, in about the position where an image of the sun could be seen if Venus had a metallic (and properly polished) surface. These observations have been confirmed (and some of them originally made) at Greenwich by Messrs. Christie and Maunder, and by Captain Tupman. Thus on January 9 and 10, 1878, "I had," says Mr. Christie, "an opportunity of examining Venus in the daytime, and I was fortunate in securing Captain Tupman's co-operation on these occasions. As seen with an ordinary eyepiece (power 500), Venus appeared as a crescent having a breadth equal to about two-thirds of the radius, with a bright arc near the limb. This arc shaded off perceptibly towards the cusps. On applying the solar eyepiece, which reduces the light (by virtue of the three reflexions from the glass) to one 3000th part, both Captain Tupman and I satisfied ourselves that there was a bright elongated patch distinctly within the limb. In the centre of this I caught glimpses of a small point of light, the distance of which from the *apparent* limb I estimated as rather more than 0·1 of the radius. The position of the point at which specular reflexion would take place I afterwards found by calculation to be 0·18 of the radius within the limb." Captain Noble had in June, 1876, under similar conditions of illumination, failed to detect any gradation of light whatever towards the limb. He recognized a patch of sensible area "without the slightest sign, trace, or indication" (we are not sure what distinction is intended to be drawn here between signs, traces, and indications) "of one part being in the smallest degree brighter than another." Mr. Christie considers that had Captain Noble looked more closely, he would perhaps have detected in the middle of the bright patch a small bright point as Mr. Christie did. Be this as it may, what Captain Noble saw, while certainly inconsistent with the theory that Venus has a simply rough surface or *mat* surface without any specular reflexion whatever, and equally inconsistent with the theory that Venus has a purely specularly reflective surface, in which case we should

not see Venus at all, but only the image of the sun in the Venerian mirror —it certainly is not correctly described by Mr. Christie as incompatible with any theory whatever. For, if the part of Venus turned earthwards at the time were covered with a great ocean, not so much rippled that the surface lost its power of specular reflection, while all the reflected images of the sun were distorted and scattered as we see them when the sun is shining athwart a rippled sea, an area of sensibly uniform illumination would be presented within the illuminated crescent of the planet's disc. A small portion near the middle of this area would be more brightly illuminated than the rest however, and if this were seen it would present the appearance of a point of light such as was seen by Mr. Christie. Certainly in the present condition of our knowledge respecting Venus, which assures us that she has an atmosphere like that of the earth, and at times very heavily laden with the vapour of water, the idea of a wide expanse of ocean surface, capable of specularly reflecting the sun's rays, and even "in seasons of calm weather" of making a nearly perfect, though at our distance an undiscernible, image of the sun (mirrored on that calm Venerian ocean), seems not only admissible, but altogether probable. The metallic surface, with its vitreous atmosphere, or as it has been called "the glorified thermometer-bulb theory," outrages common sense. Yet we find Mr. Christie, a mathematician of no mean skill, and as a practical observer free one would suppose from those tendencies which affect the *merely* mathematical mind, calmly presenting the fact that the position of the plane of polarization in the eyepiece relatively to the line of cusps appeared to have no appreciable effect on the gradation of light, "would be consistent with the theory of reflexion from a metallic surface." It would be consistent also with the theory that the spirit of the late Lord Rosse has during the last few years superintended the envelopment of the surface of Venus with a coating of speculum metal, alloyed in proportions corresponding to those used for the Parsonstown telescope; and it would be as well worth while to oppugn one theory as the other in any serious manner.

Meteoric Radiant Points.—Scarcely less absurd in its theoretical aspect, but equally useful as presenting observational facts of interest, is Mr. W. F. Denning's paper on the suspected repetition of outbursts from Radiant Points, and on the long duration of meteor showers. Noting that meteors seem to radiate for three or four months from the same radiant points, Mr. Denning, who has collected a considerable number of independent observations bearing on this point, mentions it as suggesting reasons for believing that the same meteoric systems really are traversed by the earth during these long periods of time. He says at the outset of his paper, that, "in the present very imperfect state of our knowledge it would be wrong to hastily condemn any observed facts, however improbable and incomprehensible they may at first sight appear." Condemning observed facts is certainly not a proper course for the true student of science; nor would it avail much, facts having a certain obstinate persistence, despite any amount of condemnation. There is, however, no easier way of bringing facts into question than basing utterly absurd and untenable propositions upon them. This is what Mr. Denning has done in the present instance. It is in the first place absolutely impossible that meteor systems should have the extension demanded for them

by Mr. Denning; and in the second place if they had, it is certain that the observed effects would not be those on which Mr. Denning bases his theory. If the radiant of a meteor system in January, for instance, is precisely the same as the radiant of a meteor system in April, then it is certain that the first meteor system and the second meteor system are altogether distinct from each other. For the direction of the earth's motion, on which of necessity the position of a radiant depends largely, has changed in the interval through one quadrant, that is to say, the earth in April is travelling at right angles to the direction she had in January—the same being true of any two periods in the year separated by three months. Capt. Tupman, who very promptly indicated, at the meeting where Mr. Denning's paper was read, the utter incompatibility of Mr. Denning's theory, either with possibilities or with the facts on which Mr. Denning attempted to base it, has supplied some "remarks on Mr. Denning's paper," which immediately follow it (we are glad to see) in the "Monthly Notices," and in some degree save the Royal Astronomical Society from the discredit which papers presenting untenable and unscientific theories tend to bring upon it.

Transit of Mercury.—A transit of Mercury occurs on May 6. For centre of earth the times of contact are as follows—

		Mean time at Greenwich. h.	m.	s.
External impact at ingress . .	May 6	3	12	25
Internal „ „		3	15	32
Least distance of centres, 3′ 47″·4 . . .		7	0	4
Internal impact at egress		10	44	34
External „ „		10	47	43
Angle from North Pole for direct image—				
Contact at ingress		45° towards E.		
„ „ egress		100° „ W.		

As the sun sets at 7h. 28m., little more than the first half of the transit will be visible in this country.

Other Phenomena for the Quarter.—Venus will be at her greatest westerly elongation at 6 A.M., May 2; Mercury at his greatest westerly elongation at 7 P.M., June 2. None of the superior planets come into opposition during the quarter.

CHEMISTRY.

The Hydrocarbons formed by the Action of Acids on Spiegeleisen.—Cloëz has examined the products resulting from the action of dilute hydrochloric acid (spec. gravity = 1·12) on soft cast-iron containing 0·04 per cent. chemically combined carbon, and about 0·06 per cent. manganese. As some of the hydrocarbons enter into combination with this acid, sulphuric acid diluted with five times its weight of water was subsequently used. In one experiment 200 kilog. of iron were treated with acid, and this quantity yielded 1·64 gramme of oily hydrocarbons condensed in the first washing-bottle; 2·278 grammes of brominated hydrocarbons of the ethylene series; 3·532 grammes of hydrocarbons of the marsh gas series separated by means of sulphuric acid; 4·38 grammes of solid residue; and 5·408 grammes of

oily products, removed from this insoluble portion by alcohol, and subsequently precipitated by the addition of water. The hydrocarbons of the marsh gas series retained by the sulphuric acid were removed by decantation, washed with water, and dried with fused potash, and, subsequently, with sodium. When submitted to fractional distillation it was found that the first portion passed over at 155° C, then the temperature soon rose to 160°, remaining at that point for some time. The portions which distilled between 160° and 170°, between 175° and 190°, and during successive intervals of 20° up to 300° were collected separately. These quantities were further purified by subsequent distillation and eventually seven products were obtained, each of which appeared to have a nearly constant boiling point. These are all substances which are known and appear to be identical with bodies which have been isolated by Pelouze and Cahours from petroleum. They form the highest known members of the marsh gas series, which are characterized by their insolubility in fuming sulphuric acid, and by their behaviour with chlorine and bromine. The first distillate is dekane, C_{20} H_{22}, probably identical with diamyl; it boils between 155° and 160°, has a vapour density = 5·132 (calculated = 5·001), and a specific gravity = 0·76 at 15°; bromine water is without action on this substance; bromine, on the other hand, attacks it vigorously, as also does chlorine, forming substitution products. The next body, undekane, C_{22} H_{24}, boils at 178°–180°; it is a colourless very mobile liquid having a vapour density = 5·521 and a specific gravity = 0·769; sulphuric acid does not act upon it; with bromine and chlorine, however, it forms substitution products. The next four are: duodekane, C_{24} H_{26}, which boils at 195°–198°, has a specific gravity = 0·782, and is acted upon by bromine and chlorine; tridekane, C_{26} H_{28}, boiling at 215°–220°, having a specific gravity = 0·793; tetradekane, C_{28} H_{30}, with a boiling point of 234° to 238°, and a specific gravity = 0·812; and pentadekane, C_{30} H_{32}, which boils at 258° and has a density = 0·83. The last distillate is hexadekane, C_{32} H_{34}, boiling at 276°–280°; its specific gravity is 0·85. This body is attacked by fuming nitric acid, but no crystalline product was obtained. Many of the hydrocarbons, then, which are formed by the action of dilute acid on cast iron are identical with natural products contained in the complex material which we call petroleum (*Compt. rend.*, lxxxv. 1003). We are reminded here of Mendelejeff's views respecting the origin of mineral oils communicated last year to the Russian Chemical Society (see note in the "Pop. Sci. Rev.," July 1877, p. 317), and of the occurrence at Ovifak, Disko Island, Greenland, of vast metallic masses, possibly meteoric, possibly erupted, which contain much carbide of iron.

Persulphuric Acid.—Berthelot has prepared a new acid of sulphur (*acide persulphurique*), corresponding in composition with perchloric and permanganic acid, by the discharge of electricity of high tension, though a perfectly dry mixture of equal volumes of sulphurous acid and oxygen; sulphuric acid combines neither with oxygen nor with ozone under similar conditions. The electrolysis of concentrated sulphuric acid also yields the new acid in a state of solution. It can, moreover, be prepared in a state of solution by cautiously mixing a solution of hydrogen peroxide with sulphuric acid, concentrated or diluted with not more than one equivalent of water; when two equivalents are present no reaction takes place. In the last-mentioned case the reaction

appears never to be complete, a portion of the hydrogen peroxide always remaining unchanged. Anhydrous persulphuric acid is most readily prepared by allowing the discharge to take place for eight or ten hours through the tubes constructed for such operations, by which time their interior is found to be covered with drops of a viscous liquid: at 0° it becomes solid and is crystalline; in places it has a granular structure; in others thin transparent crystals are seen traversing the length of the tubes; brilliant scales are also observed attached to the glass. The acid resembles anhydrous sulphuric acid; the latter substance, however, forms opaque crystals which are shorter, much finer and narrower than them. At 10° persulphuric acid has a vapour tension of several centimètres, and sublimes spontaneously from one part to another of the tube in which it is confined. Its composition was determined both by synthesis and analysis. After the two gases had entered into reaction the residue was removed from the tube by means of the Sprengel pump and measured: if the change takes place in accordance with the following equation the residue should be one-eighth of the gas consumed:—

$$\underbrace{S_2O_4}_{4\text{ vols.}} + \underbrace{O_4}_{4\text{ vols.}} = S_2O_7 + \underbrace{O}_{1\text{ vol.}}$$

In two experiments the numbers 8·2 and 7·9 were arrived at in place of the ratio 8·1. Four volumes of sulphurous acid and three of oxygen, therefore, appear to combine to form persulphuric acid:—

$$S_2O_4 + O_3 = S_2O_7$$

The acid was analysed by several methods: by using a standard solution of tin chloride, estimating the change by means of potassium permanganate, and subsequently determining the sulphuric acid as barium sulphate; again, by employing a standard solution of ferrous sulphate, and afterwards observing the amount of a standard solution of permanganate required to complete the oxidation; also by the use of potassium iodide and hyposulphite, as well as by the employment of sulphurous acid and potassium iodide. Each method gave numbers which indicated the formula S_2O_7 as that of the new acid. At 0°, or at temperatures below zero, the acid may be preserved for some days; it is not a stable compound, however, and after the lapse of 14 days it commences to spontaneously decompose; the aqueous solution very rapidly undergoes change; when it is dissolved in concentrated sulphuric acid the decomposition is retarded; in this case also oxygen is slowly evolved, and at the end of six weeks the acid is completely destroyed. An application of heat causes it to separate into sulphuric anhydride and oxygen. It develops dense fumes in contact with air, atmospheric moisture is absorbed, and hydrated sulphuric acid formed. Dissolved in concentrated sulphuric acid it appears, as has already been stated, to have the power, for a time, of resisting decomposition; the solution, after the lapse of the first twenty-four hours, appears, from the results of volumetric analyses, to undergo no appreciable change. When placed in contact with baryta water a portion of the acid apparently escapes decomposition and barium persulphate is produced; the salt, which could not be analysed, is soon converted into the ordinary sulphate, oxygen being evolved. Persulphuric acid does not oxidize arsenious acid or oxalic acid in the cold, and in this respect it closely resembles hydrogen peroxide; it shows a marked difference from that compound in other reactions in that it

is unable to form perchromic acid and does not reduce potassium permanganate. The author concludes his very interesting paper with some speculations on the relation of the oxides of sulphur to those of other non-metallic and of metallic elements, and promises to employ his method in the investition of the higher oxides of other substances.—*Compt. rend.*, lxxxvi. 20.

The Crystallization of Lime, Strontia and Baryta.—Brügelmann describes the chemical and physical characters of these oxides when in a crystallized condition ("Annalen der Chemie und Physik," ii. 466). The crystals are formed when the nitrate of the metal, enclosed in a porcelain flask or retort, is submitted to the very high temperature of a furnace fed with coke. All three of the oxides form crystals, belonging to the regular system, and they are invariably found to be cubes; in the case of lime, crystals having an edge one millimetre in length have been obtained. As a rule the residue left when a nitrate is treated in the manner described, has a vesicular or foliated appearance, and is apparently an amorphous mass; a low power, however, is sufficient to show that it is made up of crystals. An examination of crystals of each of these oxides in polarized light confirmed the observation that they all belong to the regular system. The lime produced from the nitrate is far less readily subject to change when exposed to the action of moisture or carbonic acid than that obtained by heating marble. These crystals (of lime) can be exposed to the air for many days without undergoing change, and to water or moisture for several hours before they fall to powder. That the materials in the hands of the author were pure oxides is proved by his analyses, which showed them to consist respectively of 99·64 per cent. of lime, 99·4 per cent. of strontia, and 99·32 per cent. of baryta.

Separation of Nitrogen from Air.—Harcourt and Lupton have found ("Chem. Central-Blatt," 1878, ii.) that in the removal of oxygen from air by passing it over red-hot copper turnings, a very large metallic surface must be exposed, since the reaction ceases when the crust of oxide attains a certain thickness. The authors compass the difficulty by conducting the air through concentrated ammonia before it reaches the copper; the oxide is in this way continually reduced. As long as the supply of ammonia is maintained a mixture of pure nitrogen and steam issues from the apparatus.

Composition of the Smoke of Virginia Cigars.—Schwarz has examined these gases by the aid of Orsat's apparatus, the use of which instrument he highly recommends for technical analysis. The products of the combustion of the tobacco were collected in an aspirator, and were found to contain 12·0 to 12·85 per cent. carbonic acid, and 4·0 to 4·76 per cent. of carbonic oxide. The presence of the last-mentioned constituent explains the deleterious action of these cigars.—*Chem. Central-Blatt.* 1878, vii.

Weights and Measures.—The German Federal Council issued, at the end of last year, a list of contractions which are to be employed in official documents to indicate the respective weights and measures, the names whereof are written beside them in the following table:

Kilometer . . .	km	Square kilometer .	qkm
Meter	m	Hectar . . .	ha
Centimeter . . .	cm	Ar	a
Millimeter . . .	mm	Square meter . .	qm

Square centimeter	qcm	Cubic millimeter	cmm
Square millimeter	qmm	Ton	t
Cubic meter	cbm	Kilogramm	kg
Hectoliter	hl	Gramm	g
Liter	l	Milligramm	mg
Cubic centimeter	ccm		

No stops are to follow the letters. The letters are to be placed after the figures which express the amount, not over the decimal point: 5,37m, not 5m, 37cm. In separating the integral numbers from those representing the decimal part a comma is to be employed in place of a full stop. The comma is not to be otherwise used when writing numbers representing measures of weight or capacity, not as formerly to divide high integral numbers; in such cases the digits are to be divided into groups of three, counting from the comma (our decimal point), and the division between the groups is to be marked by a space. The new system has been introduced in the columns of the "Chemisches Central-Blatt." (See note in "Chem. Central-Blatt," January 2, 1878, xvi.)

GEOLOGY AND PALÆONTOLOGY.

An American Jurassic Ceratodus.—In the January number of "Silliman's Journal" Professor Marsh describes an interesting discovery he has made among the vertebrate fossils obtained from the same Upper Jurassic deposits of Colorado which furnished the gigantic Saurians noticed in our last number (p. 103). This is the left lower dental plate of a fish of the curious genus *Ceratodus*, which Professor Marsh names *C. Güntheri* in honour of Dr. Günther of the British Museum. The specimen has the inner side convex and the outer divided into five projections, separated by four notches, the upper edge showing five points, of which the foremost is the longest and most widely separated. The plate is attached to a fragment of the dentary bone, and furnishes the first evidence of the existence of *Ceratodus* in America in Mesozoic times.

Silurian Land Plants.—Professor Lesquereux has described (in the "Proc. Amer. Phil. Soc.," 19 Oct. 1877) and figured some terrestrial plants from the Lower Silurian. These are *Protostigma sigillaroides* from the Cincinnati group of Ohio; and *Psilophyton gracillimum* and *Sphenophyllum primævum* from the same rocks near Covington, Kentucky.

A Carboniferous Fungus.—In the above cited paper Professor Lesquereux also describes a fungus (*Rhizomorpha sigillariæ*) found upon a Sigillaria in Cannel coal at Cannelton, Kentucky.

New American Dinosaurs.—Professor Marsh now forms a new family, *Atlantosauridæ*, for the gigantic Jurassic Dinosaur noticed in our last number (p. 103), and indicates as its more important characters the pneumatic cavities in the vertebræ, the presence of only three or four vertebræ in the sacrum and the corresponding shortness of the ilium, the large fore-limbs, and the presence of five well-developed digits in both fore and hind feet. The hind foot was ungulate and essentially plantigrade. The carpal and

tarsal bones were not co-ossified with the long bones, and the third trochanter of the femur was rudimentary or wanting.

Professor Marsh describes a still larger species of *Atlantosaurus* (*A. immanis*) which had a femur *over eight feet* long, which, taking a crocodile as a term of comparison, gives the fossil animal a length of about 115 feet; and the author thinks it probable that the reptile when alive was nearly 100 feet long, though it may have been much less. Another species, called *Morosaurus impar*, allied to *Apatosaurus* and *Atlantosaurus*, is best represented by its sacrum, which is said to indicate an animal at least 25 feet long. The genus *Allosaurus* (see p. 104) is said to present characters which render it the type of a distinct family of Dinosaurs, *Allosauridæ*, and a new species (*A. lucaris*) 18 or 20 feet long is described.

Creosaurus atrox, allied to *Lælaps*, an animal about 20 feet in length, is said to have been "the carnivorous enemy of the huge *Atlantosauridæ*." The teeth referred to it have more or less trihedral crowns, with the cutting edge crenulated. The vertebræ are biconcave.

As a contrast to the preceding giants we have *Laosaurus celer*, a Dinosaur about the size of a fox, and *L. grasilis*, a still smaller species.—*Silliman's Journal*, March, 1878.

Carboniferous Sponges.—Numerous remains of spicular bodies, believed to belong to sponges, have been recently detected in the Carboniferous shales of the south-west of Scotland, and described in more or less detail by Professor J. Young, Mr. J. Young, and Mr. H. J. Carter, in several papers published in the "Annals and Magazine of Natural History" (see especially ser. 4, Vol. XX., p. 425, and ser. 5, Vol. I., p. 128). The most interesting part of the evidence points to the existence in Carboniferous times of a sponge so nearly allied to the well-known glass-rope, that the above authors do not hesitate to refer it to the same genus, and it is here described under the name of *Hyalonema Smithii*. With regard to other species the evidence of affinity with recent forms is less striking. Mr. Carter has some important remarks on the replacement of silica by carbonate of lime in these fossils.

MECHANICS.

An Automatic Railway Brake.—In "Nature," March 21, 1878, we find a description of an automatic brake made by the Westinghouse Brake Company, and an account of some experiments on the action of a current of compressed air upon an elastic ball, which possess considerable interest. The article is really a report of experiments witnessed at the Company's offices, where the writer was shown the action of the whole apparatus necessary to stop a train of ten carriages. The apparatus works by means of air, which is compressed by a steam engine, and distributed through all the tubes and the ten reservoirs, extending over the whole length of the train; by simply turning a handle this compressed air acts upon the brakes, which, in turn, clasp the wheels; the action is so completely under control that the brakes can be applied in less than 5 seconds, and so powerful as to bring a train going 40 miles an hour to a dead stop in about 15 seconds, and within a distance of 500 yards.

The mode of action is as follows:—The compressed air is admitted into a

cylinder containing the ends of two pistons, which act by leverage upon the brakes, the admission of the air being effected by means of a reduction of pressure, which opens a set of valves communicating with the cylinder. On its entrance it pushes the pistons out, and these then act upon the brakes. A further advantage is said to be that in case of the train breaking into two or more parts, the brakes will immediately act automatically and bring the carriages to a standstill. This brake is already in use on the Midland Railway.

The experiments above alluded to, with a hollow elastic ball, were made by means of a nozzle attached to the apparatus, through which the compressed air could be allowed to escape. When the ball is placed within the current of air, with the tap upright, it is sustained as if by a jet of water, but shows little or no revolving motion. When the tap is inclined at an angle of 30° or 40°, the ball is still supported by the current, but it recedes and advances in the line of the tap and revolves so rapidly as to cause a distinct flattening of its poles, and this goes on until the ball becomes almost a disc. The axis of rotation then gradually changes until it is at right angles to its original position, when the speed of rotation diminishes, and the ball gradually ceases to revolve; then it begins rotating upon its new axis, and passes through the same series of changes repeatedly so long as it is exposed to the action of the jet.

MINERALOGY.

The Accidental Coloration of the Zeolites.—The coloured varieties of these minerals may be divided into two groups: those owing their colour to the presence of inorganic material like the red zeolites of Dumbarton and the Fassathal, which enclose hydrated oxide of iron, and those which contain organic compounds. Websky ("Jahrbuch für Mineralogie," 1878, 75) has published a memoir on the mineral species which are included in the second category. The best known minerals of this class are the brown desmin and heulandite occurring in the deposits of magnetite at Arendal; here the colour is unquestionably due to the presence of an asphalt-like substance. Similar crystals have recently been met with in druses in the granite of Gräben. The desmin of Striegau exhibits pale leather-brown and wood-brown hues. The rare crystals of chabasite have an orange red approaching a chestnut-brown colour, very intense on their surface, lighter but still relatively intense in the interior. Chabasite appears to take up the largest amount of the colouring substance. A fragment of this mineral when heated in a closed tube turns black, a small amount of a tar-like substance distilling off. The mineral is afterwards found to have a pale grey colour; if heated for a longer time in an open tube the colour disappears, at least from the surface. Two specimens of heulandite from the granite of Striegau, now in the Berlin collection, exhibited two years ago a fine citron yellow colour, now they are much paler; others are referred to which were covered with perfectly colourless crystals of laumonite. It is curious to find that minerals, like chabasite, desmin, heulandite, and laumonite, which agree so closely as regards their elementary constituents, and differ only in the proportion of these ingredients, should exhibit a very great disparity in their

power of absorbing a colour-producing organic compound, and, in cases where this compound has been taken up by each variety, that they should differ in so marked a manner in respect to the action of light upon them.

Amber.—Rehoux has published a paper in a recent number of the "Annales de Chemie," on the means whereby this substance may be distinguished from artificial amber, copal, and other bodies. Copal is yellow, more or less deep in hue, which is of the same intensity throughout the specimen, and has on its surface yellow points resembling sulphur. Amber, on the other hand, has always one end of a different shade from the other. When rubbed on the palm of the hand for a few seconds, amber emits a powerful aromatic odour; the other substances show no change when treated in this manner. By prolonged exposure to air amber sometimes loses a constituent, which the author believes to be an essential oil, and its characteristic aspect is lost. When copal is scraped with a knife the fine particles go upwards; when amber is so treated what is detached falls. Amber, when gently heated in a flame, may be bent; the other substances are not pliant. Copal melts at 100°, preserving its yellow colour; amber fuses at 400°, and blackens, emitting a distinct odour of sulphuretted hydrogen. Amber has a specific gravity = 1·09, that of copal is 1·04, and that of artificial amber is 1·05. Yellow amber has the composition:—

Carbon	78·82
Hydrogen	10·23
Oxygen	10·90
	99·95

Bolivite and Taznite.—Domeyko has recently communicated to the French Academy of Sciences some further notes on the mineralogy of Bolivia. Bolivite is the name which he has given to a bismuth oxysulphide, composed of the protosulphide $Bi_2 S_2$, and of the sesquioxide $Bi_2 O_3$. Taznite is a chlor-arsenate and chlorantimonate of bismuth which has been found at Tazna, in Bolivia. Several curious bismuth minerals are referred to in his paper.

Bischofite.—This name has been given by E. Pfeiffer to a new mineral species from the salt deposits at Strasfurt. An analysis by König shows it to consist of 11·86 per cent. of magnesium, 35·04 per cent. of chlorine, and 53·10 per cent. of water. These numbers indicate the formula $Mg\ Cl_2 + 6\ H_2 O$ as that of the mineral.

Quartz and Tridymite.—Sandberger describes some curious crystals of quartz from the Friedrich Christian mine at Shapbach, which enclose spherules or partial spherules (hemispheres), white and opaque, of the size of a millet seed, and consisting of silicic acid. When examined under the microscope in polarized light, they proved to be small masses of opal, surrounded by little crystals of tridymite. The tridymite is here found associated with copper pyrites, dolomite, and other minerals, and the observation is of interest as affording confirmation of Vrba's statements respecting the occurrence of tridymite in quartz ("Jahrbuch für Mineralogie," 1878, 47). While studying the minerals of the Rocher du Capucin, near Mont Dore, last autumn, Des Cloizeaux remarked the occurrence of crystals of hypersthene, tridymite, and zircon in the druses of the trachyte of that locality. He finds that the tridymite readily undergoes change. Blocks of stone, hewn

in the preceding spring, contained crystals of that mineral which had become altered, white and partially destroyed, the hypersthene remaining unchanged. In one locality he found a geode filled with crystallized, or rather crystalline, doubly refractive quartz, much fissured and very friable, resembling that from Radicofani, associated with which were a number of crystals of tridymite.—*Jahrbuch für Mineralogie*, 1878, 45.

Pandermite.—Vom Rath has given this name to a lime borate, which occurs in the form of rounded nodules, associated with gypsum, in a bed of clay-slate at Panderma, on the Black Sea. The new mineral resembles a snow-white, finely grained marble, and appears to have a composition expressed by the formula 2 CaO, 3 B_2 O_3, 3 H_2 O, and to be nearly related to the borocalcite of Toscana and Iquique.—*Jahrbuch für Mineralogie*, 1878, 75.

Sandberger communicated to the last "Naturforscherversammlung" a paper on the occurrence of traces of heavy metals in the minerals of the rocks enclosing metallic veins. Several specimens of olivine, hornblende, augite and mica were observed to contain, in the form of silicates, traces of the metals which entered largely into the composition of the metallic minerals traversing or associated with them. In the picryte from the Carpathians and serpentine derived from it, a small amount of nickel and a still smaller quantity of cobalt were met with. Copper occurs in the olivine of Naurod and of the Ultenthal, as well as in the palæopicryte of the Fichtelgebirge and of Dillenburg. The latter mineral contains, moreover, a trace of bismuth. In hornblende and augite, copper and cobalt were found. Specimens from Andreasberg were examined, and the presence in them of traces of lead, antimony, arsenic, and nickel, was recognized. Some micas contain as constituents lead, copper, cobalt, and bismuth; while in that variety of the mineral which forms an ingredient of the gneiss of Hörstein, the presence of arsenic was detected.—*Rev. deut. chem. Gesell. Berlin*, January 14, 1878, 2233.

PHYSICS.

Note on some Phenomena of Electrolysis.—I have much pleasure in furnishing the following note of some experiments, a preliminary notice of which was given to the Physical Society of London, on the 16th of March of this year.

Amongst the well-known effects of passing a current of chemical electricity through a non-metallic conductor are:—(1) Electrolysis, whereby the electrolyte is divided into primary and secondary products which, speaking generally, bear to one another and to the electrodes a relation homologous with that which the metals in the active cells bear to one another and to their liquids. (2) There is a bodily carrying-forward of the whole electrolyte in the direction of the current, and this is more marked according as the electrolyte is a worse conductor. (3) There is an action compounded of the above two. If sulphuric acid be electrolysed, the acidity is increased around the + electrode. If caustic soda be electrolysed the causticity is augmented around the − electrode. If sulphate of copper be electrolysed

between platinum poles, copper (as sulphate) travels to the – electrode, but not in sufficient quantity to replace that which is there deposited (Hittorf, Wiedemann).

Remembering the molecular indifference which crystalloids and colloids bear to one another, the question presented itself:—Is there, in a mixture of the two kinds of matter, sufficient continuity and mobility amongst the crystalloid molecules to establish an electric chain? If there be so,—molecular currents being wholly suppressed by the colloidal obstruction,—a valuable means would be furnished for tracing the "wandering of the ions."

Water was boiled with sufficient gelatine to form a stiff jelly. In this, while warm, a little sulphate of sodium was dissolved together with some litmus. To one portion a drop of dilute sulphuric acid was added, to another a drop of ammonia. When the jellies had set in glass cells, pairs of sheet platinum electrodes nearly fitting the cells were thrust in, about two inches apart in both cases. Six pint platino-zinc battery cells were attached to each (in succession). Flattened bubbles of gas forced themselves up from both poles with a crackling noise. In a quarter of an hour, in the slightly reddened cell, both faces of the + electrode were clothed with a brighter and more transparent red envelope, but somewhat thicker towards the other electrode. The – electrode was coated with a transparent blue envelope. These two conditions spread and met one another in about three-quarters of an hour, in a vertical plane between the two electrodes, somewhat less than twice as far from the - as from the + electrode: the blue band being the widest. This plane was maintained for three hours after its establishment with the current in action, and kept the same for days after the current had been broken; although by automatic diffusion, the blueness and redness have spread backwards. A similar effect was produced in the blue jelly. The heat developed produced a slight fusion, which was confined to the – electrode.

F. GUTHRIE.

A Point in the Theory of Brass Instruments.—A paper was read before the Physical Society, by Mr. D. J. Blaikley, on this subject. The common description of such instruments as cones, or cones combined with cylindrical tubing, was objected to as being inaccurate, as was also the opinion that horns, trumpets, &c., have naturally, of necessity, just intonation, or notes with vibrational numbers, 1, 2, 3, 4, &c., corresponding to the prime, octave, twelfth, double octave, &c. The two simple forms of resonators that give these intervals, the open tube of equal section and the complete cone, were shown, and the positions of their nodal points explained. The positions of the nodes in the cone were experimentally determined by a method which is believed to be new, and is peculiarly applicable to tubes of varying section. The conical or other tubes, the nodes of which were to be determined, were immersed in water, until the length giving the maximum resonance to a vibrating fork of the required pitch, held over the tube, was fixed by the water level. It was then shown that the action of the lips does not, at least to any material extent, affect the conditions of resonance. Various truncated cones, with and without the addition of cylindrical tubing, were then blown by the lips; none of them gave the required harmonic intervals, and it was demonstrated that this was because the position of the lips did not correspond to that of a nodal point common to all the points required. The positions of

the nodal points in a bugle of hyperbolic figure, giving the correct intervals, were then shown experimentally and explained; the difference in position between these and the nodes of similar notes on a cone being very great. The bugle used had for the pitch of its prime or fundamental note C of 128 vib., and was divided into seven semi-ventral segments for C of 512 vib. This C could be produced from each of these seven pieces, or from any combination of an odd number of adjacent pieces, and the effect of the gradual increase of curvature from the mouthpiece to the bell upon the positions of the nodal points, and consequently upon the lengths of the semi-ventral segments, was thus made apparent.

Telephonic Signals.—The telephone, wonderful instrument as it is, is still far from realizing the ideas entertained of it by the general public, who are generally inclined to fancy that the extraordinary results foreshadowed by the facetious Mr. Punch have already been attained. It is still impossible for a serious family to remain quietly in their own drawing-room on a wet Sunday and satisfy their consciences by listening there to the suave eloquence of some popular preacher; for ladies of musical tastes to enliven their soirées with melodies "wired" from Covent Garden or the Haymarket; or for scientific amateurs to enjoy the discourses delivered for their delectation at the Royal Institution without the labour of travelling to Albemarle Street. Telephonic utterances sound as if they came "from the back o' beyont," to use an old Scotch phrase; and even these faint adumbrations of speech can only be perceived when the receiving instrument is held close to the ear of the listener. Hence arises a difficulty, namely, how is the intended recipient of a message to be warned that a communication is about to be made? for it is obviously too much to expect that the persons at the two ends of a telephonic line shall sit perpetually with the instruments applied to their ears. Mr. W. C. Röntgen indicates ("Nature," December 27, 1877) that a warning may be given by means of a battery and alarum attached to the telephonic system, but that this will cause so great an addition to the cost of establishing and maintaining a telephonic apparatus that it must be dismissed as inadmissible. His own plan is to give a signal of the intended transmission of a message by means of a tuning-fork placed close to the end of the bar magnet, opposite to that which acts in reproducing the vocal sounds. He proposes to effect this by providing the second pole with a coil of wire inserted in the circuit at this point, and connected with the general circuit in a manner easily understood but hardly explicable without a figure. "Before this pole of the magnet," he says, "may be very easily set up a tuning-fork, which, with the telephone, is simply fixed to a resonance case; this arrangement should be made at both the transmitting and receiving stations, and both forks should be in unison. If now the sending station wish to signal that a communication is to be begun, the fork of that place will be sounded with a fiddle-bow; the currents thereby induced in the coil are powerful enough to set the fork of the receiving station in such intense vibration that the sound may be distinctly heard in a large room." Mr. Röntgen says that he has made this experiment in a room containing about 100 people, all of whom could hear the sounds of the fork, which was a König Ut_4. The author has made some experiments which are of interest. One is of importance in connection

with the reproduction of the clang-tints of tones through the telephone. If in one of the two telephones a higher fork be substituted for the Ut_4 one and this is sounded with the fiddle-bow, "there will be heard with another inserted telephone of the ordinary construction tones of even 12,000 double vibrations per second, a sign that the variations of the magnetic condition of a magnet perceptibly occur, even when the forces producing these variations change their size 24,000 times in a second." In another case he used the telephone to test the electric vibrations indicated by Helmholtz and others as produced in the induced coil by the opening of the primary current of an induction apparatus, when the ends of the former are connected with the armatures of a condenser. The telephone was inserted in the circuit between the coil and the condenser. When the ends of the induced spiral were not connected with the condenser, he heard a dull report in the telephone; when these ends were connected with the condenser, this report was accompanied by a shorter, higher sound. The observations were made with a telephone having a very thin and deep-toned iron membrane.

At the meeting of the Academy of Sciences of Vienna, on February 14, Dr. J. Puley suggested another application of tuning forks to telephonic signalling. He proposes to remove the vibrating plates from two connected telephones when not in action, and to place opposite the coils the limbs of two tuning-forks of as nearly as possible the same tone. On the other side of each tuning-fork is placed a small bell, and between this and the fork a little brass ball is suspended so as to touch the latter. When the fork at either end is set in vibration by means of a small iron hammer coated with leather, the fork in the other station also vibrates, and sounds the bell by means of the little ball. When the signal is answered from the receiving station, the vibrating caps are put on the telephones, and conversation can be carried on. Dr. Puley has also made experiments with steel reeds, such as are used for the harmonium. With a resonance box, the tone is so strengthened at the receiving station as to be perfectly perceptible in a large room. The bell-signal is so loud as to be audible in an adjoining room with the door closed.

The Ultra-violet Spectrum has been studied by M. Cornu in a paper brought before the French Société de Physique, on February 15. He employs the ordinary ray from a prism of Iceland spar, which forms the more deviated and the more widely dispersed of the two spectra. He replaces the glass or metal reflector of the Heliostat by a prism of quartz giving total internal reflection. He uses quartz object glasses, ground specially for obtaining the minimum of aberration, the shape being that of a crossed lens, very nearly plano-convex, with its flatter curvature outwards. He concentrates the light on the slit by means of a convex lens also of quartz. It is thus found that the spectrum varies with the time of day, having a maximum about midday. It is longer in winter than in summer. To obtain the normal spectrum, he draws all the lines of the prismatic spectra on a large scale, then determines the wave-lengths of some, and calculates the others by interpolation. He also employs diffraction gratings, but substitutes in this case the electric spectrum of iron for that of the sun, which is of feeble intensity in the ultra-violet tract. He has carried this region somewhat further than had been previously done.

Lightning Conductors.—M. Melsens has erected a series of lightning-

conductors on the fine old Hôtel de Ville at Brussels. Instead of single rods he employs bunches or groups of points, branching out in all directions, connected with numerous ramified conductors meeting in a solid block of galvanized iron, from which three series of ramified wires sunk like roots in the ground are connected, one communicating with a well under the court, the two others passing through iron pipes full of gas tar, until they reach the gas and water mains of the town.

Toughened Glass.—An improved method of producing annealed or toughened glass has been adopted by M. de Labastie. He throws the soft articles, immediately on their being blown, at once into the annealing bath, so as to save a second heating, and the consequent danger of loss of shape.

Automatic Gas Lighting.—An ingenious plan for accomplishing this object has been brought before the Society of Arts by Mr. Fox. Each lamp is supplied with a small induction coil, the primary wires of all being united, and the secondary with condensers composed of glass plates and tin foil laid alternately side by side. The soft iron core of the induction coil is also used to produce reciprocating horizontal motion in a permanent horseshoe magnet suspended on needle-points just above the coil. A stop-cock is actuated by the reciprocating magnet, and thus the gas can be turned on immediately before the lighting spark passes. The whole apparatus is contained in an air-tight metallic case, measuring 2½ inches high by 2½ inches wide, screwed on to the supply pipe of the lamp, the insulated wire being either carried underground, or as in some experiments now in progress in Waterloo Place and Pall Mall, hung from small telegraph poles attached to the tops of the lamp standards.

The Compass of Ancient Flutes.—M. V. Mahillon has been able to reproduce successfully the tone and scale of the ancient flutes found at Pompeii.

A similar determination was made in 1876 by Mr. W. Chappell and Dr. Stone for facsimile copies of the Egyptian flutes preserved in the British Museum, and in that of Turin. These were exhibited and played on during the Loan Exhibition of Scientific Instruments at South Kensington. The reed then used was that which can be made from a simple joint of long grass by means of a longitudinal flap cut upwards towards the closed node. This, the most ancient form of reed, as described in "Tyndall on Sound," is often made by children in the fields, and called a "Squeaker," and still exists in the drones of the ordinary bagpipe.

M. Mahillon made use of a similar single beating reed, to be found in the *Arghoul*, or Egyptian flute. Taking for granted what is rather matter of doubt, namely that the chromatic scale was known to the ancients, M. Mahillon concluded that if the thirteenth sound obtained was the octave of the first, the intermediate notes must be correct. Thus B, on the second line of the Bass clef is obtained as the fundamental or lowest note of the instrument, and the following notes are successively obtained by opening the lateral notes, C sharp, D, E, F, F sharp, G, G sharp, G sharp, A, B flat, B natural. The absence of C and of D sharp is accounted for by the fact that the second and fifth rings of the instrument are not bored. It is possible this may be due to the fact that they would, if open, exceed the number of the digits, though M. Mahillon does not advert to this point. The

duplication of G sharp, however, throws some doubt on the correctness of the scale.—*Pall Mall Gazette*, March 18.

The Phonograph essentially consists of two parts, a recording instrument, and another for deciphering and reading aloud the record thus obtained.

The former has a mouthpiece stopped at its inverse end by a metallic diaphragm carrying a point. In close approximation to the point, a metal cylinder covered with tinfoil is made to rotate in a spiral. The tinfoil being left unsupported behind by a spiral groove of similar pitch cut in the cylinder, is indented by the point with depressions corresponding to the vibrations of the metallic plate. The permanent record thus obtained requires deciphering, an end which is obtained by the other portion of the instrument. This consists of a similar diaphragm held in a tube on the opposite side of the cylinder, attached to another point pressed against the tracing by a delicate spring. The original vibrations are thus transferred to a second membrane, and reproduced in the form of sound. The machine has been exhibited before several London Scientific Societies with complete success. Mr. Preece brought it under the notice of the Physical Society on March 2. Two forms of the instrument were illustrated. In one, the receiving and emitting disks are distinct, one being of ferrotype iron, and the other of paper; in the other, both functions are performed by one and the same disk of iron. In one, moreover, the drum is moved by hand; in the other by a train of wheels and a descending weight, regulated by an adjustable pair of vanes. Sounds emitted by the paper disk appeared to be more distinct than those from the iron. Professor Fleeming Jenkin suggests that the Phonograph may be found of value in throwing light upon the nature of vowel-sounds, and confirming or correcting Helmholtz's theory. A full detail of experiments made by him and Mr. Ewing on the subject is promised.

Ice as an Electrolyte.—Messrs. Ayrton and Perry have forwarded to the Physical Society a second communication on Ice as an Electrolyte. In their former paper they described experiments proving that as the temperature of ice is allowed gradually to rise, the conductivity increases regularly, and that there is no sudden change in passing from the solid to the liquid state. They also roughly determined the specific inductive capacity of ice and water at $-13°{\cdot}5$ and $+8°{\cdot}7$ Cent., showing that at the latter temperature it is 2,240 times as great as at the former; there being very little change in the capacity up to 0° Cent., nor after that point; it was expected that a very great change must occur at the melting point. In their second paper approximate curves have been traced from $-12°{\cdot}2$ to $+5°$ Cent. by charging for 10 seconds, and then short-circuiting for 15 seconds. The change at the melting point, though quite as sudden as expected, on the whole realizes their anticipations. "The important theory," they remark, "which Professor Clerk Maxwell has developed, by comparing the propagation of electro-magnetic disturbances through the ether with the propagation of light-vibration, has been illustrated only by paraffin, a non-conductor; and he has not considered the propagation of electro-magnetic disturbances in a conducting medium. But according to a former paper on the "Viscosity of Dielectrics," no dielectric can be affirmed to be non-conducting, and the charging of any condenser whatever is always accompanied by absorption

phenomena; also absorption certainly increases with conductivity. Hence, although, if a method of experimenting were employed in which a water-condenser of great internal resistance were discharged through wires of less resistance for shorter and shorter periods of time, the measured specific inductive capacity might get less and less, and gradually approach a value equal to the square of the index of refraction of water for infinitely long laminous waves (the index of refraction for air being called unity); still, practically, the measured specific inductive capacity can never be even approximately equal to the refractive index of water, since the absorbed charge is immeasurably greater than the surface-charge." We therefore need not expect to find the specific inductive capacity of water in its variations with temperature consistent with Dr. Gladstone's results for index of refraction.

New Form of Battery.—M. P. Jablockkoff describes to the Académie des Sciences a pile in which the attackable electrode is of coke. This substance not being attacked by any liquid at ordinary temperatures, heat was needed, and a substance which would only become liquid at a sufficiently elevated temperature, and be converted into vapour only at a still higher.

He fused nitrate of potass or of soda, and immersed in it as the attackable electrode ordinary coke, with platinum as the unattackable. For the latter, however, iron answers equally well. The electromotive force of this battery varies between two and three units. It is, therefore, superior to that of Bunsen or Grenet, the former of which gives 1·8 unit, the latter 2·0, or at best 2·1 units.

Previous fusion of the nitrate is not necessary. It is sufficient to ignite a piece of coke, and place it in contact with the powdered salt. The heat produced fuses the salt, and action begins. The action is not at all rapid. Much carbonic acid and other gas is liberated, and is stored up to act as a motive power.

Incrustation in Boilers.—The value of zinc in this capacity is now fairly established; and is probably due to galvanic action. Facts have been collected by M. Brossard de Corbigny; and M. Lesueur has stated the case of a steamer repaired in 1861 at Havre. It had three boilers, one of which, fed direct from the sea, was almost wholly oxidized and useless, while the others, which were fed with water from the condenser, were in perfect preservation. The condenser showed that the brass partitions were reduced to a comparatively pure spongy copper, the zinc having disappeared entirely. It was concluded that zinc could be made to act as a scale-preventer. In 1876 M. de Corbigny was requested to examine closely all the evidence, and to report to the Ministry of Public Works. The application of the zinc was generally in the simplest form, it being placed in a part of the boiler removed from the furnace. It was found that, with fair water, containing but little calcareous matter, the deposits, instead of forming adherent scale, were in the state of fluid mud, and easily removed by washing. If, however, the feed-water was strongly calcareous, the deposits were coherent and strong, but did not adhere to the iron, being easily removed by the hand, assisted by a scraper. The zinc was in time found to be reduced to a white earthy-looking oxide, consisting of 87·30 per cent. of this substance, with 3·80 of oxide of iron and aluminium, and 6·20 of lime carbonate.

No zinc was found in water drawn from the boilers. The opinion stated was that a small but continuous disengagement of hydrogen is maintained over the whole surface of the iron in contact with the water, the bubbles forming a film which separates the metallic surface from the scale-forming substance. —*Engl. Mechan.* March 3.

Currents of High Tension.—M. Planté employs secondary batteries of high tension made of plates of lead which constitute powerful accumulators of Voltaic electricity. By associating a number of batteries containing from 400 to 800 of these couples, a discharge is obtained equal to from 600 to 1,000 Bunsen batteries arranged for tension. All are arranged in simple circuit, and can be charged in a few hours by some Grove's or Bunsen's cells. By turning commutators all can be united in tension, and the enormous quantity of electricity thus accumulated made use of in a few seconds. If two copper wires be inserted in water, contained in a flat glass cell, acidulated with $\frac{1}{10}$th of sulphuric acid, and connected with such a secondary battery, or even with 15 or 20 Bunsen's batteries, a thick cloud of protoxide of copper issues from the end of the positive wire. If a strong magnetic pole be brought into the neighbourhood the cloud assumes a spiral form, of which the component rays turn in a left or right-handed direction, according as the pole is north or south.

ZOOLOGY.

On Lingula.—Professor E. S. Morse has communicated to the Boston Society of Natural History the results of an investigation of the structure and habits of *Lingula*, which he made on the coast of Japan. In a species of this curious and interesting genus of Brachiopods he discovered auditory capsules, resembling in position and general appearance the corresponding organs described and figured by Claparède in certain tubicolous annelids. The circulation in *Lingula* he maintains to be due entirely to ciliary action, and he altogether denies the presence of anything like a pulsatory organ. With regard to the habits of *Lingula* he states that when it is partially buried in the sand the anterior margins of the pallial membranes contract in such a way as to leave three large oval openings, one in the centre and one on each side. The long bristles of this region are then arranged in such a way as to form funnels leading directly to the openings, and these funnels acquire firm walls by the accumulation upon the bristles of the mucus flowing from the animal. A constant current is seen passing down the side funnels and up the central one. The *Lingulæ* bury themselves very readily in the sand, and the peduncle agglutinates a sand tube, by means of which, when in confinement, they attach themselves to the surface of the vessels.—*Silliman's Journal*, February 1878.

Solid-hoofed Deer and Pigs.—In our notice of the "Bulletin of the United States Geological and Geographical Survey of the Territories," we have mentioned that Dr. Coues has described the occurrence of a solidungulate condition in the Virginian deer, and in a peculiar Texan breed of pigs. Of the case of the deer, though not uninteresting, little need be said; the consolidation having been apparently observed only in a single specimen, and being confined to the horny hoof itself, the bones of the foot retaining their

normal character. In the pigs, on the other hand, the terminal phalanges of the toes have become united in the middle line, producing a single broad terminal phalanx, above which, however, the other phalanges of the toes remain perfectly distinct. Dr. Coues says, "The upshot of this modification of the foot is that a strictly artiodactyle animal is transformed into an imperfect perissodactyle one;" and from the characters presented by the terminal phalanx, even in a young animal, he is of opinion that its condition is "not the result of progressive confluence of the two bones, but of their original connation." The horny hoof encases the bones as far as the distal extremities of the proximal phalanges, and is perfectly solid, although in front there is a slight vertical line indicating the limits of the two halves. On the sole of the hoof there is a broad, angular elevation of horny substance, apex forward, and shaped so as to be curiously like the frog of the horse's hoof.

The occurrence of solid hoofs in the pig, as of cleft hoofs in horses and asses, has already been observed occasionally, but in the case of these pigs a regular solidungulate breed appears to have been established, and so firmly that no tendency to revert to the original form is observed in them. Mr. Marnock, of Helotes, Bexar County, who has furnished Dr. Coues with information and specimens, states "that the cross of a solid-hoofed boar with a sow of the ordinary type produces a litter the majority of which show the peculiarity of the male parent."

A New Chimæra.—Mr. T. Gill has announced his recognition of a new American species of the curious genus *Chimæra*, which he proposes to name *C. plumbea*. It is of a uniform lead colour, with the snout acutely produced, the anteorbital flexure of the suborbital line extending a little above the level of the inferior border of the orbit, the dorsals close together, the dorsal spine rounded in front, the ventrals triangular and pointed, and the pectorals reaching the outer axil of the ventrals. The only known specimen of this fish, which is a most interesting addition to the Atlantic fauna, was taken south-east of the La Have bank, at a depth of 350 fathoms, with a bait of halibut.—*Silliman's Journal*, March 1878.

The Mosquito an Intermediate Bearer of Human Parasites.—On the 12th of January it was first publicly announced that the female mosquito had been found capable of sucking up the young of *Filaria sanguinis hominis* (*F. Bancrofti*, Cobbold) when feeding on persons whose blood happened to contain these parasites (hæmatozoa). The discovery, for as such we must now regard it, was due to Dr. Patrick Manson, who acts as physician to the Missionary Hospital at Amoy, China. So far back as the year 1866, the late Dr. Wücherer detected a little nematode worm in the urine of a patient. He was at the time in search of the hæmatozoon known as *Bilharzia hæmatobia*. Curiously enough, he did not find the Bilharzia; nevertheless, only a few years later (1872) Dr. Cobbold, when engaged in examining the urine of a little girl from Natal, who passed thousands of Bilharzia eggs daily, encountered the embryonic nematode worm that Wücherer had been the first to observe. About the same time Dr. Lewis also detected the worm in a chylurous patient, and later on he made the remarkable discovery that the same microscopic nematode infested human blood. A few years afterwards Dr. Bancroft not only discovered the hæmatozoon, as such, in Australia, but on December 21, 1876, he made the important discovery of

the existence of the same entozoon in the sexually mature state. This worm was first described by Dr. Cobbold in the "Lancet" for October 6, 1877, and named after its discoverer. As regards the immature worm many similar finds were at different times made in various countries, by Drs. Salisbury, Sonsino, Crevaux and Corré, Foncervine, O'Neill, Silva Araujo, Da Silva Lima, F. dos Santos, and others; moreover, Dr. Lewis himself, only a few months later than Bancroft, verified the fact of the occurrence of the mature worm in the human body. Drs. Araujo and dos Santos have also found the full-grown worm. If the early announcements were received with incredulity, there does not seem much room left for doubt now. On March 7 Dr. Manson's investigations were brought before the Linnean Society with ample illustration and considerable minuteness of detail. From the remarks made after the reading of Manson's paper, followed as it was by a lengthened memoir on the part of Dr. Cobbold, reviewing the whole of the known facts as recorded by himself and some twenty other different observers, there seemed to be no escape from the conclusion that mosquitoes were true intermediate hosts, whose express duty it was to carry or nurse (as Manson says) the larvæ of the human nematode called *Filaria Bancrofti*. Further, it appeared that this entozoon was not only associated with, but the actual cause of several endemic affections, such as chyluria, hematuria, lymphoid diseases, elephantiasis, varix, and so forth. Professor Allen Thomson thought that the authors had fairly proved their case; and Sir Joseph Fayrer stated that he regarded the subject as one of unparalleled interest. In the course of the discussion Mr. McLachlan suggested the possible influence of fishes as intermediary bearers, whilst Mr. Curling, Dr. Collingwood and others testified from personal knowledge as to the conscientious character of Dr. Manson's work.

Hungarian Saltwater Rhizopods. — The third part of the Hungarian "Naturhistorishe Hefte," for 1877, contains an interesting paper by Dr. Geza Entz, on the Rhizopoda obtained from a pool of salt water at Szamosfalva, near Klausenberg. The species obtained, which are fully described and figured, are:—*Pleurophrys helix*, sp. n., *Plectrophrys prolifera* g. et sp. n. (allied to *Plagiophrys*, *Pleurophrys* and *Chlamydophrys*), *Euglypha pusilla* sp. n., *Microcometes tristrypetus* sp. n., *Orbulinella smaragdea*, g. et sp. n., *Ciliophrys infusionum*, Cienk., six species of *Amœba* (*guttula, limax, princeps, diffluens and radiosa*), and *Podostoma filigerum* Clap. and Lachm. Thus out of twelve species, five are described as new, and all of these are enclosed in capsules. From a previous investigation of the Infusoria of the salt ponds of Torda and Szamosfalva, the author arrived at the conclusion that while a portion of them had previously only been found in the sea, the greater part occurred both in salt and fresh water, but only a fourth part of the Infusoria obtained belonged to forms previously known only from the latter. With regard to the Rhizopods, the greater number are forms which are very abundant in fresh water, but are probably to be referred to the category of organisms common to both fresh and salt water; of the species peculiar to the salt pool, the closest allies of two (*Euglypha pusilla* and *Microcometes tristrypetus*) have hitherto only been found in fresh water, whilst the nearest relative of another (*Pleurophrys helix*) lives in sea water. Of the two new genera, one (*Orbulinella*) is related to the perforated marine Foraminifera,

and the other (*Plectrophrys*) to *Pleurophrys*. As a negative character, he remarks that the *Arcellæ*, which are so abundant and so easily found in fresh water, and the equally abundant and characteristic *Difflugiæ*, are wanting in the salt pond just as in the sea.

Marine Amœbæ.—In the fourth part of the same periodical Dr. Entz notes the confirmation of his previous supposition that the *Amœbæ* observed in fresh water and in the salt pools, may also occur in the sea. In sea water from Cuxhaven he found two *Amœbæ* (*A. limax* and *radiosa*) very abundantly. He regards *A. marina*, Duj. and *A. polypodia*, Schulze, as probably identical with *A. radiosa*, and possibly also Häckel's *Protamœba polypodia*.

Young Limuli.—Mr. Alexzander Agassiz writes as follows to "Silliman's Journal":—"Mr. C. D. Walcott has called attention to the fact that when collecting fossils he finds large numbers of Trilobites on their back.* From this he argues that they died in their natural position, and that, when living, they probably swam on their backs. He mentions, in support of his view, the well-known fact that very young *Limulus*, and other crustacea, frequently swim in that position. I have for several summers kept young horseshoe crabs in my jars, and have noticed that besides thus often swimming on their backs, they will remain in a similar position for hours, perfectly quiet, on the bottom of the jars where they are kept. When they cast their skin it invariably keeps the same attitude on the bottom of the jar. It is not an uncommon thing to find on beaches, where *Limulus* is common, hundreds of skins thrown up and left dry by the tide, the greater part of which are turned on their backs. An additional point to be brought forward to show that the Trilobites probably passed the greater part of their life on their back, and died in that attitude, is that the young *Limulus* generally feed while turned on their backs; moving at an angle with the bottom, the hind extremity raised, they throw out their feet beyond the anterior edge of the cenopace, browsing, as it were, upon what they find in their road, and washing away what they do not need by means of a powerful current produced by the abdominal appendages."—*Amer. Jour. Sci.*, January 1878.

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* "Ann. Lyc. Nat. Hist., N. Y.," Vol. XI., p. 155, 1875. "Twenty-eighth Report, N. Y. State Museum," Dec. 1876.

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